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THE BALTIC STAMP MILL: LAKE SUPERIOR COPPER REGION.

The recently completed Baltic stamp mill at Redridge, Mich., handles the rock from the Baltic mine, which is a property owned by the Copper Range Consolidated Co. It is typical of the modern milling plants which have been erected in recent years by various mines in the district, and is a good example of modern stamp-mill design. Fig. 1 is a plan and Fig. 2 is a general view of the plant. At the right of the view is the coal storage, adjacent to the boiler house, beyond which is the mill. Coal is delivered by railway cars into pockets supported by the steel trestle. The rock is delivered into the great rock house or bin on the upper side of the mill. Water is supplied from a reservoir, and after passing through the mill flows across the beach into the lake. The entire plant was designed by Mr. F. G. Coggin, Superintendent of the stamp mills of the Baltic Mining Co., who also supervised the erection and now superintends the operation of the Baltic, Atlantic and Champion mills. To him we are indebted for courtesies shown during a visit to the plant, and for information and drawings used in the preparation of this article.

GENERAL VIEW OF BALTIC MILL; REDRIDGE, MICH.
Baltic Mining Co.; F. G. Coggin, Superintendent.

The entire plant, mill, boiler house and trestle approach, is of permanent steel construction. The foundation walls are of sandstone rubble masonry; the trestle and interior foundation piers are of concrete. The mill building and boiler house are of steel frame construction, with steel roof trusses; the walls are of timber sheathing, covered with corrugated iron, and the roofs are of plank with magnesia covering. The columns are I-beams and built-up H sections, the latter being used for small columns where the width of I-beam flanges would be insufficient. All the steel work was built by the Wisconsin Bridge & Iron Co.

The boiler house contains five 250-HP. Stirling water-tube boilers, set in three batteries and equipped with Andrews' shaking grates. The other equipment includes a Green fuel economizer; a Nordberg triplex belted boiler feed pump, a duplex spare steam boiler feed pump; two 150-in. fans (with Reeves variable-speed device) for induced draft, one for service and one spare; and a 10 × 18-in. Nordberg Corliss engine which drives the fans, the triplex pump and the economizer mechanism. The mill equipment consists of four Nordberg steam stamps, a Nordberg horizontal tandem-compound Corliss condensing engine, with cylinders 13 × 36 and 23 × 36 ins.; a 28 × 14-in. Nordberg double belted condenser; and a 54-in. × 14-ft. Baragwanath feed water heater. The engine drives the jigs, concentrating tables and all mill machinery, as well as a 30-KW. direct-current direct-connected generator. A marine set of 4 KW. is provided for use when the engine is not at work. Each stamp is provided with an auxiliary Sturtevant centrifugal roll 36 × 5 ins. The complement of concentrating machinery for each stamp consists of 6 four-spigot hydraulic classifiers or sizers, 24 double compartment eccentric roughing jigs, 4 Wilfley and 7 Overstrom concentrating tables. A regrinding plant consisting of one 6-ft. Anaconda type Huntington mill with 7 Overstrom concentrating tables, is located in the basement. All piping for the jigs is laid under the floor. A trolley hoist on an I-beam runway over the stamps is provided for handling engine parts; the roof is high enough to allow the trolley to lift a stamp engine cylinder and carry it over the cylindersof the other stamps. Fig. 3 is a view on the upper floor of the mill, showing the steam cylinders of the stamps; it also shows the condensers and the overhead trolley.

Coal is delivered to the coal pockets from 35-ton cars, thence distributed by gravity over the storage plateau adjacent to the boiler house by tram cars running on steel trestles. This plateau is a timber platform supported by walls of heavy log-cribbing. In summer the coal is shoveled direct into small cars which dump into openings in the boiler house wall, the coal falling onto the firing floor in front of the boilers. In winter, however, the coal is taken through adits or tunnels under the coal platform, the roof of each tunnel being formed by loose boards, which can be removed to allow the coal to flow in, where it is loaded onto the cars. The boilers are fired by hand. The ashes from the boilers are led by inclined ashpits to a tunnel in front of the boilers, whence they are continuously flushed by water from the overflow of the main service tank. When the mill is working at such capacity as to use the entire supply from the tank, a special pipe from the reservoir will deliver water under head at intervals for flushing out the tunnel. All boiler house drainage is led to this tunnel. Water for all purposes, amounting to approximately 10,000,000 gallons per 24 hours, is obtained from a reservoir formed by a steel dam on the Salmon Trout River (Engineering News, Aug. 15, 1901). The head of water from the dam to the supply tank is 17 ft., and to maintain a uniform head, the water flows into a standpipe, connected to the service tank by a pipe with valve for regulating the supply of water and the water level in the tank.

The steam stamps or stamp mills are of the Nordberg type, with cylinders 20 × 24 ins. Each stamp strikes 108 blows per minute; the weight of the striking parts is 2½ tons. The mortar of each stamp weighs 13 tons and rests on cast-iron anvil blocks weighing 87 tons, which in turn rest on concrete foundations. These foundations are piers 20 ft. square and 32 ft. high, founded on bed rock. The concrete for 22 ft. from the bottom is in proportions of 1 part Portland cement to 3 parts sand and 5 parts stone; for the upper part the proportions are 1: 2: 4, and this upper part is reinforced by sheets of wire screening, ⅜-in. wire and 2-in. mesh. These sheets are 1 ft. apart, vertically.

The usual practice has been to place timber cribbing under the concrete or between the concrete and the stamp mortar, in order to absorb shocks and vibration, but this also absorbs some of the force of the blow. At the Baltic mill there is no provision for elasticity; the mortar being anchored solidly to the concrete and the concrete built directly upon bed rock. It is of course nec-

essary to anchor the mortar very rigidly to the concrete, as any play or lost motion would cause the stamp to batter it to pieces. With this arrangement, less steam is required to crush a given amount of rock, or more rock can be crushed with a given amount of steam, than where provision for elasticity is made in the foundations.

Fig. 4 is a view of one of the stamps, showing the mortar, and the rock feed. Fig. 5 is a cross-section of the mill, showing the stamps and foundations and also the arrangement of the concentrating machinery.

In the operation of the steam stamps, to produce a blow sufficiently heavy, the valves are set for a late cut-off on the top end. On the bottom end, only sufficient steam to raise the stamp shaft needs to be admitted, so that by far the larger volume of steam is used on top. It will be evident also that the effect of the vacuum may be removed from the top end without impairing the striking efficiency of the stamp. Advantage is

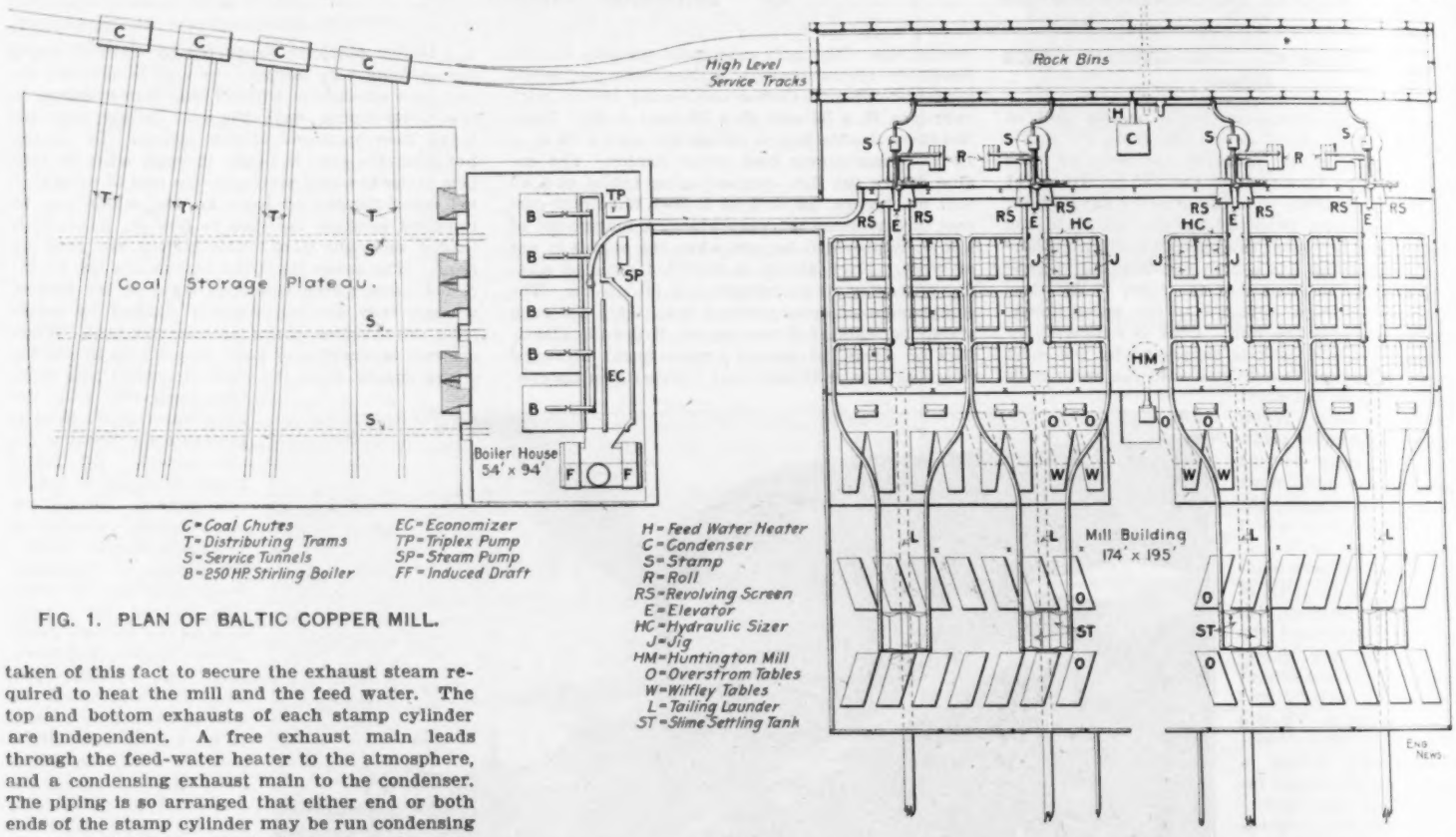

FIG. 1. PLAN OF BALTIC COPPER MILL.

taken of this fact to secure the exhaust steam required to heat the mill and the feed water. The top and bottom exhausts of each stamp cylinder are independent. A free exhaust main leads through the feed-water heater to the atmosphere, and a condensing exhaust main to the condenser. The piping is so arranged that either end or both ends of the stamp cylinder may be run condensing or non-condensing, as desired. In normal operation, three stamps run full condensing; in the fourth the exhaust is divided, the top steam going to the feed-water heater and the vacuum on the bottom exhaust being still maintained. The only loss attending the large gain is the small amount of steam which is needed on the bottom end to offset the absence of vacuum on top.

In the steam lateral leading to each stamp is a large receiver separator, so that the steam at the stamp throttle is practically dry. The feed-water is taken from the condenser hot well at 110° F., leaves the feed-water heater at 200° F. and goes by gravity to a surge tank in the boiler house, in which are also collected all the trap discharges from the steam main and receiver drainage system and the heating system. The triplex pump takes its suction from this tank and delivers the feed water through the economizer into the boiler at 300° F.

The rock is delivered from cars of 42 tons capacity into bins in the rear of the stamps which have a capacity of 2,600 tons, above the level of the discharge openings to the stamps. Below this level the bins are filled with waste rock. The arrangement of the mill is such that from the time the rock is dumped until it is delivered as crushed tailings at the other end of the mill, all operations are conducted by gravity.

Each stamp is equipped with a mortar provided with screens having ⅝-in. round perforations, and the product through these screens is delivered first upon revolving screens having ¼-in. round perforations. The screenings from the latter go at once to the concentrating machinery below. The material too large to pass through the revolving screens was formerly returned by an elevator to the mortar of the stamp to be further reduced, thereby greatly reducing the capacity of the stamp. According to practice first introduced in the Baltic mill, this material is now elevated to an auxiliary Sturtevant roll, with which each stamp is provided, and there sufficiently reduced to pass through the revolving screens.

When the pulp has all finally passed the revolving screens it first goes to hydraulic sizers which deliver four sizes of relatively coarse material, and an overflow containing the finest material, technically termed "slimes." The coarse material is delivered upon jigs. These are boxes kept continually filled with water, and consisting of two connecting compartments in one of which a horizontal screen of 8 to 12 mesh is set about 3 ins. from the top, and in the other of which a vertical plunger operates. The sized material flows across these screens and forms a bed upon them. The action of the plunger, forcing water in regular pulsations through this bed, so loosens it that the released copper, by reason of its greater specific gravity, sinks to the bottom and there collects, while the lighter gangue (or rock) is forced over into the tailings or waste. The copper is then automatically removed. Material made up of copper and sand fine enough to pass through the screens is continually passing through the screens on the jigs into the compartment underneath. This material is continuously drawn off, settled in settling tanks, and the settled material delivered upon tables called "finisher" tables. These tables have a plane horizontal surface approximately rectangular in form, covered with linoleum. This surface is given a longitudinal accelerated reciprocating motion, having a slow forward throw and a quick return. The surface has a slight incline to one side and a thin film of clear water is allowed to flow transversely from the upper to the lower side. The material above mentioned being delivered on the head of the table, the action is such that the heavier copper settles, clings to the surface and travels ahead, while the sand, more or less in suspension, is swept to the side and away. The copper travels the length of the table and is removed. Fig. 5 is a section of the mill, and Fig. 6 is a view on the lower floor of the mill. The jigs are placed in a series of steps a[illegible] rear, while in the front of the view are the [illegible]entrating tables.

In the "tailings" or waste from the [illegible]screens is a considerable quantity of coarse [illegible]rticles which contain copper not released. This [illegible]aterial, called "middlings," and amounting in [illegible] mill to about 50 tons per 24 hours, is automat[illegible]lly removed from the screens before it can go into the waste, and taken to the Huntington mill, where it is ground fine and treated on tables similar to these just mentioned. The slimes or [illegible]erflows from the sizers are conducted to settling tanks, and the settled material treated on tables similar to those mentioned.

The sources of fine (in size) copper in the mill are therefore the jig screens, the finisher tables, and the slime tables. In addition to these are several sources of coarse copper: 1, masses picked from the rock before it enters the mortar of the stamp; 2, nuggets of virgin copper, varying in size from a filbert to a cocoa nut, which are taken directly from the mortar of the stamp by means of a hydraulic discharge. This consists of a pipe, with proper valves, leading from the interior of the mortar to the outside, through which a stream of water under high pressure is injected into the interior of the same. The force of this stream is so graduated that the heavy copper drops into the pipe, while the lighter gangue (or crushed rock) is kept back; 3, nuggets of smaller size which are discharged by similar hydraulic discharges located in the launders or flumes leading from the stamp to the sizers. These various products go to make up the mill yield of "mineral" which is shipped in steel cars to the smelter.

RESULTS:—The mill was originally designed to handle 2,000 tons of rock per 24 hours, or 500 tons per stamp. The addition of the rolls has increased this to over 600 tons. The stamps require 300 boiler HP. each, and the driving engines 150 HP.

Pittsburg coal showing an average of 13,000 B. T. U. per lb. is used. In the boiler house is a permanent equipment for the testing of boilers, and the plant under working conditions shows an evaporation of 9.5 lbs. of feed water per lb. of coal from and at 212°F.

The rock treated in the mill contains approximately 27.5 lbs. of metallic copper per ton of rock, or 1.07% by weight; of this 21.5 lbs. are recovered and 5 to 6 lbs. lost in the tailings. An 80% ex-

traction is therefore indicated. The cost of milling the rock is between 18 and 20 cts. per ton.

The cost of power for milling in the Lake Superior copper district is soon to be very materially reduced. A compound Nordberg stamp, recently designed and operating in the Osceola mill, shows a 50% saving in fuel. Certain other interests are working on a plan to reduce the rock with gyratory crushers and rolls, doing away with the stamp altogether for certain classes of rock. The latter plan, if successful, will show a still further reduction in the power used for milling and in the final cost per ton.

RIVER DISCHARGE, MEAN VELOCITY, AND CROSS-SECTIONAL AREA CURVES.*

By F. W. Hanna.†

In obtaining a discharge curve for a stream-gaging station, it is customary to consider the discharge in second feet to be a function of the gage height in feet, the former usually being plotted as abscissas and the latter as ordinates. To avoid the laborious methods of determining the complicated functional relation between discharge and gage by higher mathematics, a curve is drawn through and among the plotted points by inspection. Where conditions of channel, current and wind, where accuracy of meter, correctness of gage and carefulness of engineer have all conjoined in getting a well-distributed system of measurements for a station the task of constructing the most probable curve is not difficult; but when any one or more of these favorable conditions is lacking the disagreement of the plotted points will make the location of this curve doubtful in a part or all of its length. In addition to this conflict of data for certain parts of the curve there will be portions that are not located by any measurements whatever. In such cases it becomes practically impossible to describe the discharge curve so that it shall be satisfactory without calling to aid information from other sources. Inasmuch as the discharge of any river is the product of the area and mean velocity for that stage, the most convenient and logical place to seek for guidance is in these related functions. It is easier to follow changes in these variables individually than as a product. Any study, therefore, that will throw light upon the nature of either of these functions will give valuable knowledge as to the location and nature of the discharge curve.

To find some approximate law governing the area curve, it will be necessary to make some assumption as to the character of the cross-section curve of a stream. To meet this necessity, in order to be strictly accurate, it should be assumed that the profile of any stream cross-section consists of a series of arcs of parabolas whose axes are vertical. Since the arcs may be taken long or short, since each parabola may have a different parameter or may be convex outward or inward, and inasmuch as a straight line is a limiting condition of a parabolic arc, the above statement, while having the quality of being very general and comprehensive, has the merit also of being capable of very close approximation to the actual conditions. From this principle the degree, variability of degree and direction of the area function may be developed, but the results are very complicated and less elaborate, and at the same time just as useful, information may be obtained by assuming *the profile of the river cross-section to be composed of a series of short, straight lines.*‡ Under this assumption the cross-sectional area will be made up of a series of rectangles and trapezoids promiscuously placed one on top of the other. Since the lengths of the straight lines may be assumed to be very short, no very great error will be involved in formulae based on this rectilinear assumption.

Under the last assumption, using areas as abscissas and gage heights as ordinates, by the aid of calculus, the writer has deduced the following facts: (1) When a channel is perfectly rectangular, the area curve is a straight line; (2) when a channel is perfectly trapezoidal, the area curve is a parabola with a horizontal axis extending to the right; (3) when a channel is a promiscuous series of trapezoids, the area curve consists of a series of parabolic arcs with varying parameters and with horizontal axes, which extend to the right, except in the case of an overhanging bank, or banks, the direction of the axis is reversed. As the area curve changes from one of these parabolic arcs to another, the degree of curvature suffers an irregular variation that depends for its magnitude upon the change in the slope of the river banks. Assuming that the gage increments are all taken equal, if the area increment receives any sudden increase in value, as it would where there is a sudden decrease in the slope of the banks, there is a corresponding change in the direction of the curve to the right. If this increase is due to a horizontal line in the stream cross-section profile preceded and succeeded by vertical banks, the change in the curve is a sharp angle; if to a gradually sloping line, the angle will be rounded off. Again, if the area has been increasing rapidly for gage increments and suddenly begins to increase less rapidly, caused by one or both banks becoming more nearly perpendicular, the degree of curvature will suddenly be decreased and the curve will become flatter. If at any place in the cross-section the banks become perpendicular the curve proceeds on a straight line. Finally, it is evident from the nature of the area curve that it is always concave toward the area axis.

From the above deductions, the following facts concerning the area curve must logically be inferred. The construction of any area curve must be preceded by a careful study of a complete profile of the river cross-section. If the cross-section is perfectly rectangular or trapezoidal, the area curve may be drawn by plotting a few salient points and by drawing through them a straight line or a parabola, as the case demands. However, if the channel is irregular, varying from one form to the other, as is almost invariably the case at all gaging stations, the construction of a reliable area curve can be made only by computing, from the elevations of the cross-section profile, the area for numerous heights of gage throughout its range of variation, plotting these results and drawing through them the resulting curve. Such an area curve will serve the triple purpose of discovering errors in area computations, detecting scour, or fill of channel, and assisting discharge curve construction.

The matter of determining the nature of the mean velocity curve is not an easy task. The fact that so many varying and doubtful elements, such as roughness of bed, slope, area of cross-section and wetted perimeter, enter into its composition, makes it in a large degree indeterminate. The Chezy formula,

$$V = c\sqrt{rs},$$

with Kutter's value for c, is probably the best formula from which to obtain information. Let

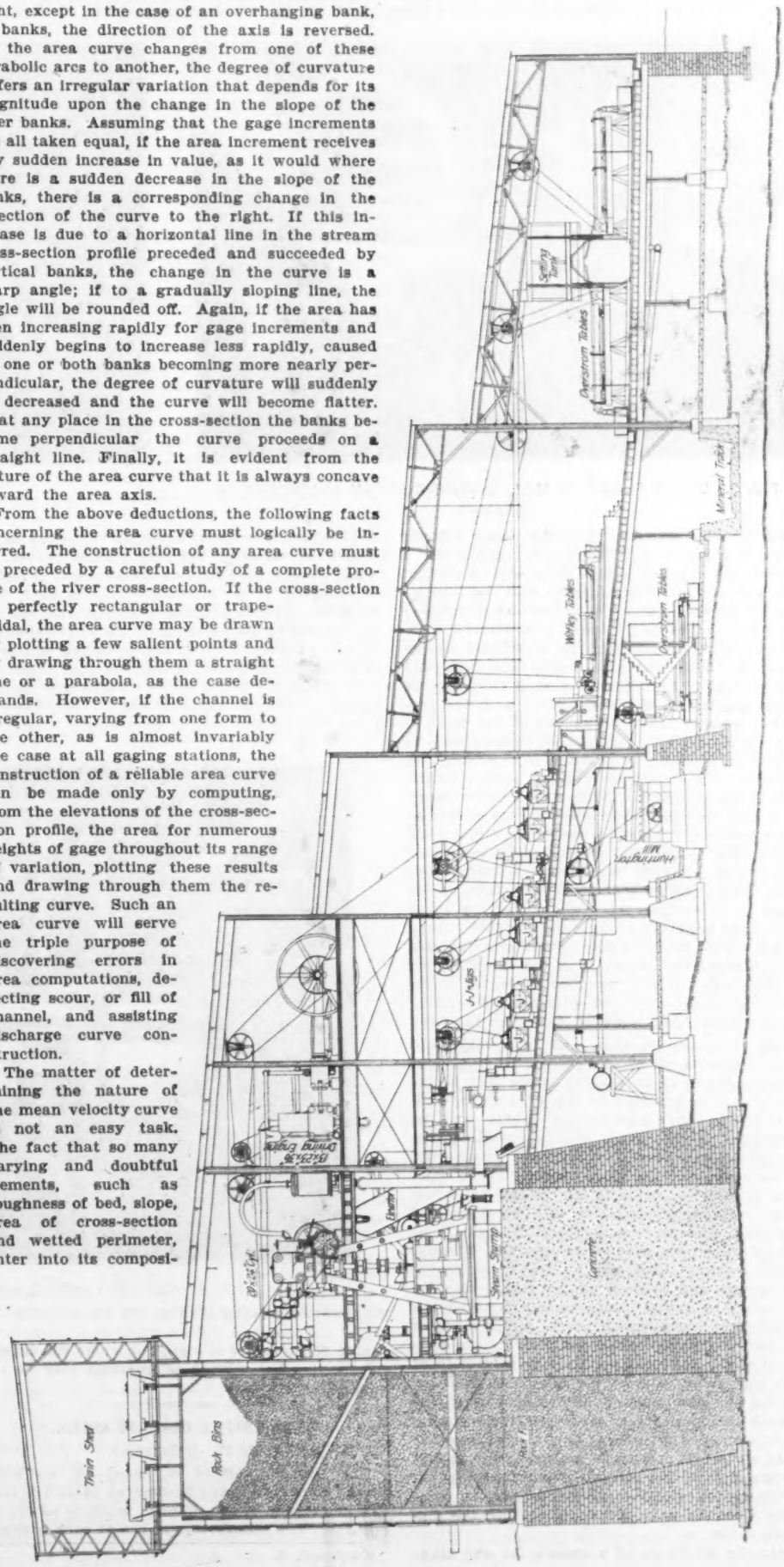

FIG. 5. CROSS-SECTION OF BALTIC MILL, SHOWING STAMPS AND CONCENTRATING MACHINERY.

*Abstracted from a paper presented at the Hydrographic Conference of the U. S. Geological Survey, held at Washington in January, 1905.

†Assistant Engineer, U. S. Geological Survey, 618 Boylston Building, Chicago, Ill.

‡The curves, equations and deductions contained in this article are based on a complete mathematical analysis of the river discharge problem, based on this assumption, but omitted at the request of the editor.

this formula be written in the following manner:

$$V^2 = C^2 s \frac{x}{p},$$

where x is the cross-section area of the river and p its wetted perimeter. Now if x be expressed in terms of the gage height as was suggested under the discussion of the area curve, and if s, c and p, in this equation, be considered constant for the moment, then the mean velocity curve is a parabola with its axis vertical for a rectangular channel, a hyperbola with a vertical axis for a trapezoidal channel, and, for the irregular channel, a series of hyperbolas with varying eccentricities and usually with vertical axes. In the last case the axes of the hyperbolas become horizontal when the area below any trapezoid base multiplied by twice the sum of the tangents of the angles that the banks make with the vertical is greater than the square of the base of that trapezoid. This condition of channel may be satisfactorily used as a criterion to determine the actuality of a seemingly reversed portion of the mean velocity curve. While the mean velocity curve may be expected to resemble the curves as above outlined, it must be remembered that their shapes may be modified somewhat by variations in s, c and p, which have been considered constant. The effect of c and p is invariably to increase or accentuate the concavity of the curve toward the gage height axis for increasing gage heights. The effect of s may act either to increase or to decrease the concavity of the curve toward the gage axis. It may even go so far as to reverse the curve where the criterion for reversal does not exist; this, however, is seldom the case.

From the above equation and deductions from it, the following points for guidance in the construction of the mean velocity curve may be inferred: All fluctuations in the area curve and, therefore, in the cross-section profile will be transmitted to the mean velocity curve. These fluctuations will usually, though not necessarily, be less abrupt in the mean velocity curve than in the area curve, owing to the counter-balancing effects of wetted perimeter and coefficient of roughness. The curve may, therefore, usually be expected to be more uniform in progress. Finally, a mean velocity curve may be drawn by inspection through and between plotted mean velocities determined by actual measurements, by studying carefully the cross-section profile for increase in area and wetted perimeter, by studying the conditions of the banks of the river as to growth of grass and trees, and as to other obstructions affecting the roughness of the bed, and by studying each measurement to see whether the stream was in a state of permanent flow at the time that it was made. Such a curve will be of use in discovering defects in current meters, testing the relative accuracy of measurements, and, by combining with the area curve, in locating the discharge curve.

Since the discharge of a stream for any stage is the product of the area and mean velocity for that stage, then it follows that the discharge curve must contain all the complications contained in both the area and mean velocity curves. The second derivative of this curve serves to show, however, that under the assumed constancy of s, p and c the discharge curve may be expected to be concave toward the axis of discharge. Fluctuations in the slope, roughness of bed, and wetted perimeter cause irregular variations in the degree of concavity, but they seldom, if ever, reverse it. By keeping this fundamental principle of concavity of the discharge curve in mind, then by carefully constructing the area and velocity curves and by taking the products of the abscissæ of these curves for the corresponding abscissæ of the discharge curve for various gage heights, a very satisfactory and reliable curve may be obtained. These products should be obtained for every foot or half foot of gage height where the degree of curvature is high, but where the curvature approaches zero these intervals may be increased somewhat.

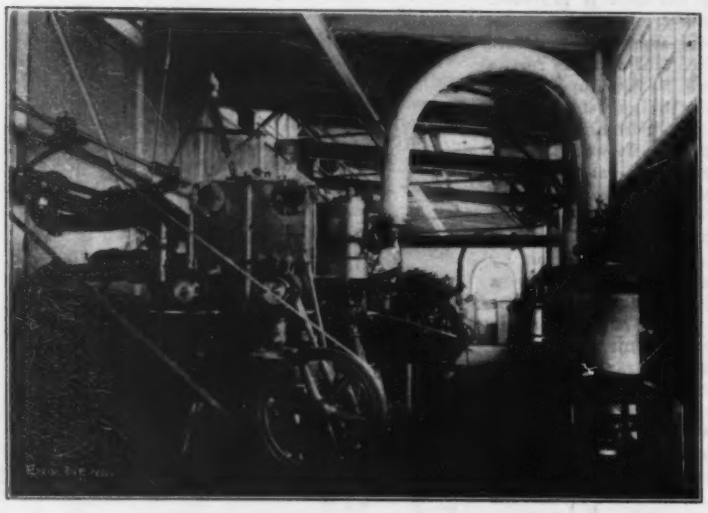

FIG. 3. UPPER FLOOR OF MILL, SHOWING STEAM CYLINDERS OF STAMPS.

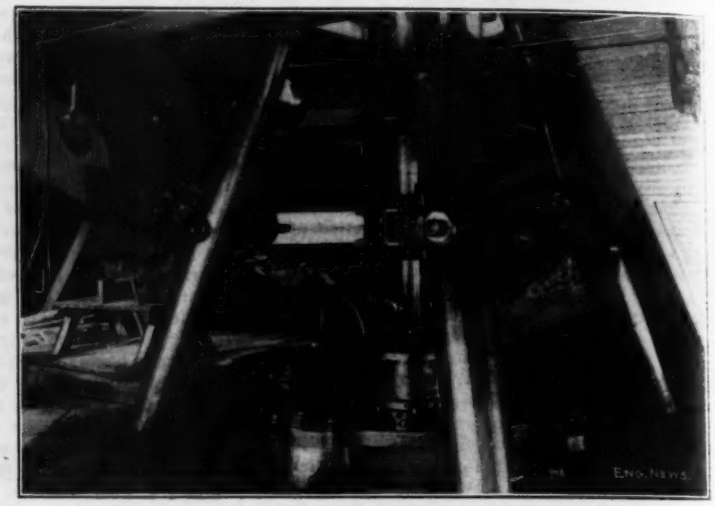

FIG. 4. MORTAR OF STAMP MILL.

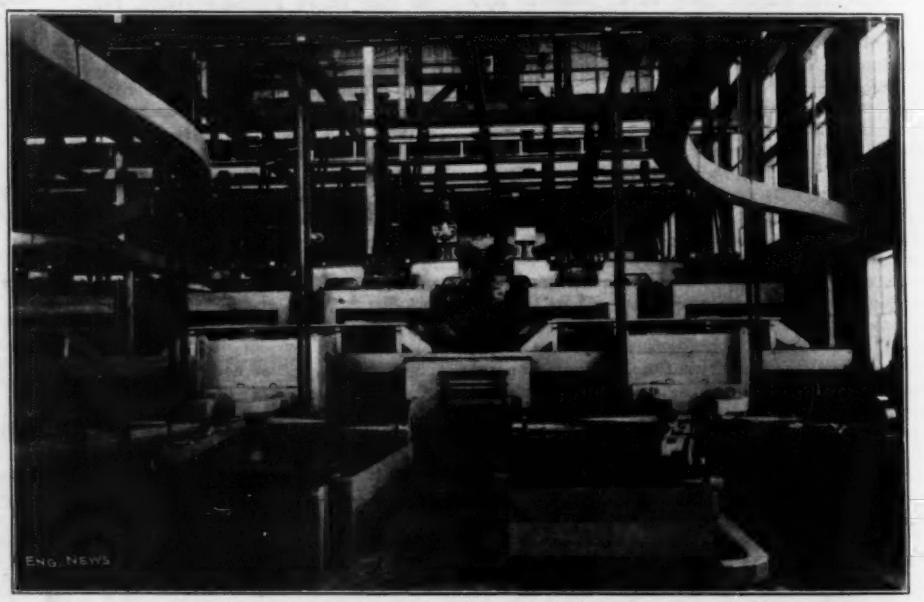

FIG. 6. CONCENTRATING MACHINERY OF THE BALTIC MILL.

(On the higher level are the jigs, arranged in a series of steps; on the lower level in front are the concentrating tables.)

BRIDGE OFFICE DRAFTING RULES.

By H. G. Tyrrell.*

The drafting offices of many of our large bridge companies have become so extensive that it is important to use uniform methods as far as possible. The actual rules in use at each particular plant will vary more or less to suit the practice and facilities of that plant. The following are drawn up as a general guide, and may be modified more or less, to suit particular cases. If the office force be small, containing, say, no more than ten to twelve men, it may be superintended entirely by one Head Draftsman. But if the number of draftsmen be greater than this, the office should then be divided into squads, containing from four to eight men each. In this way one Head Draftsman can superintend the work of from 40 to 50 men. For large offices containing more than 50 men, it will be economical to have two or more divisions, giving to one division all the work of one kind, and to the others work of a different kind. For example, one division might have all the building work, another division all of the railway bridge work, and another all of the highway bridge work. Each division will then have its own Head Draftsman and the various divisions may work independently of each other. When divided into squads, a leader or squad foreman is selected for each, who is held responsible for all the work done in that squad. Each squad should be assembled by itself. It will be necessary for the squad foreman to give considerable of his time to the supervision of the work, but after that he too will be a worker. He should be a competent engineer, for on him will fall the work of designing all the principal details, which is even more important than determining the stresses and sections, since the life of a structure

*Cincinnati, O.

depends largely upon the character of its details. He must make the rough sketches from which the material is ordered, and either order or check the order for such material. He must check the detail sheets, sizes and general dimensions.

It will be necessary to have one man for checking the work of each squad, and this man should work under the direction of the Head Draftsman, and not under the squad foreman. He will in this way have greater liberty to change any work that may appeal to his judgment as faulty.

In a large office of 40 to 50 men, it will be best for the Head Draftsman to give all of his time to the general supervisian of the work, rather than to spend any of his own time on details. He must keep a complete memoranda of when all papers were received, when drawings were started and when completed, the date when such drawings or any part of them were sent into the shop, and any further notes, so he can tell at a moment's notice what progress has been made on any piece of work. For this purpose it will be convenient for him to have a pocket note book, ruled to allow one column for each kind of information that he is likely to need. A great amount of data can in this way be carried in a small pocket note book that is always at hand. It is better that he should give his orders only to the squad foreman, and not to the various members of the squad, as this will save confusion.

The Head Draftsman should possess not only a good knowledge of structural engineering, both theoretical and practical, but should be an executive man as well. He should be a natural or trained leader, so that no friction will occur among those that work under his direction.

The subdivision of labor is one of the best means of securing good results. It will then be best to give as far as possible, all work of the same kind to the same lot of men. The drawings of that kind of work will then be made all in the same general way, and the shop workmen that use these drawings will become familiar with them. To illustrate the point, consider a plant requiring the services of say 50 draftsmen. Such a plant would no doubt have more or less machine work, in connection with movable bridges, hoisting or conveying plants, etc. It will then be best to have two or three of these draftsmen for machine work only. Then the drawings received by the machine shop will all be made in the same way by the same lot of draftsmen, and the two sets of men will understand each others methods. On the other hand if such drawings were made by any of the 50 draftsmen, there would be constant misunderstanding between draftsmen and machinist, and errors in consequence. And while this method of subdividing work, is not so pleasant for the workers, giving them no chance for variation, it will produce much better and less expensive results.

In connection with building work, there will be more or less architectural work, and it will be well to have one trained architectural draftsman in the office. In order to secure the contracts for structural work in a building, it is sometimes necessary for the company to furnish complete or partially complete architectural drawings. Or on bridge work where there is much competition, it is sometimes desirable to have perspective drawings or even water color paintings made to show to the buyers. The extra expense of these is trifling, when compared to the large profits frequently made. On such work as this the services of an architectural draftsman, can be used to advantage.

Consider then an office of 50 men. It will contain a Head Draftsman, three mechanical machine draftsmen, one architectural draftsman, five checkers, and, say, five squads of eight men each, including the squad foreman. The Head Draftsmen will then confer with the five squad foremen and the five checkers, which with his other duties, arranging matters with other officers, the contracting department, and the shop foremen, will easily occupy all of his time. And while each draftsman will keep a time card giving the number of hours spent on each piece of work, the Head Draftsman must, in a general way, keep count of any days missed through sickness or otherwise.

When received in the drafting office the contracts will be numbered. These papers should be furnished the drafting office in duplicate, one set for the Head Draftsman to retain for reference, the other set for the squad foreman. Instructions should all be written. As the squad foreman will probably have several pieces of work on hand at the same time, more or less completed, it will be well for him to keep a separate file for the papers and correspondence of each contract. As further instructions are received by him during the progress of the work, these too should be written down. He will do well also to keep a record of when work is received and completed, how many sheets of plans to each contract, and what amount of time was spent on each, so he may have a fair idea of the amount of work being done under his direction. Good draftsmen should produce from 30 to 40 sq. ft. of finished drawing per week, including the correcting of drawings after they are checked. Beginners will produce not over half that amount. On ordinary bridge and structural work, the cost of shop drawings complete including the design of details, order bills and shop lists should not exceed $1 per sq. ft.

PRELIMINARY SKETCHES.

On receiving contract papers, the first duty of the squad foreman is to make preliminary sketches from which to order the material. Some engineers prefer to use two scales for this work, a small one for the general outline and a larger scale for the joints and details. It is, however, the practice of the writer to make all such studies on a small scale, say ½-in. per ft., using the same scale throughout. Many errors of proportion are detected in this way simply by inspection, and many parts are drawn rather to suit a practiced judgment than to conform to rules and figures. In such cases the use of a single scale will greatly assist the eye. All that is necessary on these sketches is just enough drawing that the material, including all the details, may be ordered. The joints should be carefully studied out, and the number and size of all detail pieces determined. To do this it will be necessary to show the number and location of all rivets in and about the joints. Where several pieces come together, the rivets are first located, using spacing not less than three diameters of the rivets and then the outline of the connecting plate is drawn to include all the rivets. The size of rivets ordinarily used for various sizes of bars and beams, is given in any of the mill hand books which the draftsman must have at hand for reference. On heavy or important work the center lines must intersect at points, so to avoid eccentricity. On small roof trusses and other light framing, where the stresses are small, the various pieces should come together in such a way as to make a neat connection, without special regard for center lines or points. Occasionally when the finished work is wanted quickly, and the material is known to be in the factory yard, in long stock lengths, then it will be necessary to determine the lengths only roughly so that the stock may be reserved especially for that contract. In such a case the buyer has usually to pay a higher price, for the reason that in cutting long lengths, considerable stock is wasted. If, however, there is sufficent time to order the material from the mill, all in the proper lengths, then it is necessary to have the preliminary sketches made carefully. If properly started the work will progress smoothly, but if the first studies be wrongly made, then there will be nothing but confusion till it is finished. Straight pieces like roof and side girths and purlins, may be ordered directly from line diagrams without further drawing. If purlin splices occur at alternate panels and these splicing points be staggered, it will add greatly to producing a stiff frame.

ORDERING MATERIAL.

It will be convenient to have printed forms on which to write down the material. One piece such as a truss or a column should be scheduled at a time, and then the total number of such pieces given. After the material has all been written down in this way, it should be recopied before sending the order to the mill. In the finished copy, all shapes and sizes of the same kind are given together. The order bill will contain two separate columns of lengths, one being the finished length of the piece in the structure, and the other the length in which it is ordered. Short pieces should come in long multiple lengths. Multiple lengths for plates that are difficult to handle long, should not exceed about 20 ft. Angle bars and other stiff sections, may come in 30 or 40 ft. lengths. Long angles should have two to three inches excess length. Plates that are cut on a skew, can by using a little care be ordered in multiple lengths so to cut without much waste. Beams and channels should be ordered, say, ½-in. shorter than the finished length so to give the mill some little variation. If beams are required with a less variation than ⅜-in. either shorter or longer, then a higher price is charged. In ordering rods and eye-bars that will have finished heads for pins, proper addition must be made to the lengths for forming such heads. Tables of these additional lengths may be found in several of the mill hand books. If plates and angles are to be heated and bent then some extra length must be ordered, leaving a piece to be cut off after the bend has been made. In case there should be any difference in the quality of the material, such as part medium steel and part soft steel or iron, these should be kept separate. Pieces such as columns that must be planed off on the top or bottom, must be ordered ½-in. long for this purpose. Cover plates for chords and flanges, must be rolled on the edges as well as the face, and are called "universal mill plates." Pins for bridge trusses that must be turned, are ordered 1-16-in. larger than the finished size. For laterals and other less important joints where cotter pins are used instead of pins with nuts, cold rolled shafting may be used without turning, cut to the proper lengths. Corrugated iron is ordered in even lengths from 4 to 8 ft..

In ordering matched lumber, add ⅛ to estimated quantities for lumber over 1 in. thick, and 1-5 to 1-6 for lumber 1 in. thick and under.

In the case of ordinary punched and framed beams, framing plans may be sent direct to the mill, and beams will then be shipped direct to their destination.

MASONRY PLANS.

When preliminary sketches have been made and material ordered, a sketch of the bridge seat or building foundation should be made. Unless the contract for the foundation is included with the structural work, which is seldom the case, it will be necessary to sketch only sufficient to show the relation between steel and foundation. In the case of bridges give the relative height of floor and bridge seat. Give also the clear distance between faces of abutments, and the extreme length over the steel.

The foundation plan for buildings must show the location of all walls and piers with all general dimensions. There should also be a detail of one pier, giving the exact location of anchor bolts. If the trusses rest on a wall then give a detail of the truss shoe and the method of anchorage. If the building has steel columns and curtain walls, then give a detail of how the brick work fits into the columns. A copy of this plan should then be sent to whoever is putting in the foundation.

LAYING OUT WORK.

The work of laying out is a continuation of the design, started in the preliminary sketches. If this design be simple, the preliminary sketches may be all the laying out that is necessary, and draftsmen can proceed to make shop drawings from these sketches. In any case it is very important to have the drawing started right with all the pieces arranged as they should be. It is generally easier to redraw a sheet, than to make the necessary corrections to one that has been wrongly laid out.

The connections of other parts to the one being drawn should first of all be detailed. If left till other parts are drawn these connections which are the most important, are liable to interfere with some miner details, which could just as well be drawn to suit the principal connections. Purlins for corrugated iron must be located to suit the lengths of sheets, in even feet from 4 to 8 ft. allowing for a 4-in. lap on the sides and a 6-in. lap on the roof. In the same way the width of monitor can be made to suit the length of shearing. In all simple construction it will save much time to lay out directly on cloth, using the pencil

as little as possible, and drawing directly with ink. But with complicated work, it must be first drawn out and figured in pencil on paper. The maximum outside dimensions of pieces for shipping, will be fixed by office practice. They should not exceed 8 ft. in width, 10 ft. in height and 30 ft. in length, for ordinary work. In special cases, however, such as long girders, it may be necessary to ship on two or more cars, in which case the length may run up to from 60 to 100 ft. or even more.

In figuring the number of rivets required at the joints, it is convenient to take the shearing and bearing values in round numbers. Wherever practicable it is also convenient to use metal sufficiently thick, that the bearing value of a rivet may be at least as great as its shearing value. The strength of ⅝, ¾ and ⅞-in. rivets may therefore be taken at 2,000, 3,000 and 4,000 lbs., respectively. This will give results quite as satisfactory and with much less labor than if values are figured out to single pounds.

In large angles with two rows of rivets in each flange, there is no section of the metal saved by staggering the rivets in one flange with those in the other. Take for example the case of a plate girder. The rivet spacing in the web will first be figured. Those in the cover plate may then be located directly opposite to the rivets in the web, placing rivets on the inside gage line, opposite to those in the outside gage line in the other leg. This will save much time that would otherwise be required in figuring out staggered spacing, and will at the same time avoid having any flange rivets interfere with web stiffeners. In other cases, however, where there is but one row of rivets in each leg, these should be staggered, not only to avoid waste of section, but also to make it easier to drive the rivets. Wherever possible such stagger should be figured out exactly. Partly staggered spacing presents a very poor appearance in the finished structure.

A good designer will use stiff bracing as far as possible, rather than rods and pins that are liable to become loose and rattle with the passage of loads.

It has previously been stated that good details are the life of a steel structure. Much care should then be taken to have the joints stiff. Where more than three rivets are required in the end of a member to resist the tension or compression, it is best to fasten such members by rivets through both legs, using lock angles for this purpose. The scale used must be large enough to show the details clearly. For shop drawings it will generally be from ¾ to 1½ ins. per foot. Wherever possible one size of rivets should be used throughout. This will avoid the liability to error in field connections. If one or two members of a truss have flanges too small for the regular size rivets, it will often be cheaper to increase the size of the member rather than to change the size of the rivets. In light truss work where 2-in. angles are commonly used, ⅝-in. rivets will be convenient. Where rivets are used only for the purpose of resisting direct stresses, then it will be economical to use the largest size that the member will permit, and thereby save in the total number driven. In other cases where rivets are used simply to make tight joints, or to hold the several parts of a built member together, then it will be economical to use smaller rivets, as they are more easily driven. By the use of a little care it will usually be possible to make gussets and connection plates symmetrical in shape and thereby add greatly to the appearance of the structure. In chords of trusses where stresses increase towards the center, by running the heavier member slightly past the panel point, the rivets can be arranged to give symmetrical plates. The required thickness of pin plates at the holes must be determined and sufficient rivets provided to transfer their portion of the stress into the chord section.

At the end of buildings, if the wall does not extend above the roof, then the roof purlins must be bolted down to a wall angle or each individual purlin bolted down to the wall. If the roof overhangs at the ends then there should be a fascia plate or finish angle to cover the ends of the purlins. In designing posts or other members made of channel bars see that the flanges are turned out, so the lattice may be machine riveted. If the flanges are turned inward, the lattice will probably have to be riveted on by hand, as it is difficult to insert the arm of a riveting machine in between the two channels. Where struts are formed of two angles placed back to back, stitch rivets must be placed not over 2 ft. apart to prevent the angles from spreading. The same rule applies to such pieces as the various members of roof trusses made of two angles. Where the pieces are always in tension these stitch rivets may be placed further apart, say 3 to 4 ft.

Small lattice trusses should be cambered about 2 ins. in 100 ft. The corresponding amount at each panel point should be noted on the drawing.

TRACING DRAWINGS.

As the finished drawing is the final object in view, it is very important to have the tracing neatly made. Plain block letters and figures written vertically are most easily read. Wherever the size of scale will permit, lines should be made firm and heavy. For smaller scales the lines used must be lighter and greater care must then be used to show the details clearly. Dimension lines should be made in very fine black lines, either dotted or continuous. Red does not print well. It is necesasry, however, to have such lines very fine and uniform, as otherwise they may be confused with the drawing itself. If there is any doubt as to the make up of a section, it is then best to show a cross-section giving on this the important dimensions. It is poor practice to combine views, such, for example, as showing the cover plate and the chord lattice on the same view. Cloth and paper are cheaper than men's time, and it is better to use a little more of this material in showing extra views than to have any confusion in the shop. It is best to use not over three or four standard sizes for drawings. A size of 30 × 40 ins. is convenient for all ordinary work. For extra long pieces, the length of 40 ins. may be increased to whatever length is required, keeping the width the same. Then in filing these sheets they may be folded and placed in the same drawers with the regular ones. For keeping a record of castings or other standard pieces that are liable to be used repeatedly, small sheets about 12 × 18 ins. may be used. Blue prints of these may be made and pasted into a book called the Casting Book. This may then be kept for ready reference. In many cases the same patterns for castings can be used repeatedly, and it is convenient to have the drawings of these at hand. Each casting will have its own pattern number.

By means of a rubber stamp the following information should be placed in the lower right-hand corner of all drawings: Contract number; number of sheet; total number of sheets in the job; name or initials of the draftsman and the checker; date and scale. Above this may be placed with another stamp the name of the bridge company. After being stamped, the figures may be blackened with india ink, using a heavy pen or brush. The contract number should be put in large figures so it will strike the eye at once. Adjacent to this in the lower right-hand corner should be placed the title, printed in plain vertical letters. Wherever possible the making of pieces in rights and lefts should be avoided. It is better to countersink a few extra rivets, or to drive a few more than may be necessary for other reasons, to avoid having pieces in pairs. The erector is very liable to get the left-hand piece where the right should be, and not discover the mistake till it is too late.

After the tracing has been completed, the whole should then be enclosed in plain border lines, and the drawing trimmed with shears to the standard size.

In marking the size of holes it is well to state whether such holes are for bolts or rivets.

Small roof trusses of say 40 ft. and under had better be shipped all in pieces, shop riveting only the gusset plates and other such details. The total number of pieces required must be plainly marked on each drawing.

STANDARD DETAIL BLANKS.

For such parts as eye bars, pins, loop rods, clevices, turnbuckles, fork eyes, washers, etc., the shops have standard blank forms that may be filled out for each case. Illustrations of these may be seen in any book of shop standards, such as published by the rolling mills, or in Prof. Johnson's book on Framed Structures. Since the development of tall building construction, the shops have forms also for the various kinds of fram... beams and channels. On these sheets the dime... sions may be filled in. The use of these for... is a great saving of time. An extra blank fo... for miscellaneous details will be found conve... ent. A convenient size for these sheets is 8 × ... ins., or ordinary cap size, 8 × 13 ins. These blan... are printed on a fine but strong linen paper th... will stand erasing and at the same time is th... enough for blue printing. There has been an ... fort made in some shops to standardize the va... ous parts of highway bridges, such as chor... floorbeams, shoes, posts, etc. But the variation ... such parts is usually so great that very little ... indeed any at all is saved.

CHECKING DRAWINGS.

It has previously been stated that in order t... give the checker the greatest liberty, it is bett...

CHECK LIST—BRIDGES.

End Posts,
Top Chords,
Intermediate Posts,
Shoes,
Bed Plates,
Floorbeams,
Stringers,
Stringer Shoes,
Stringer Bracing,
Bottom Struts,
Shoe Struts,
Portals,
Top Struts,
Knee Braces,
Portal Braces,
Sway Struts,
Sway Frames,
Sidewalk Brackets,
Scuppers,
Fence,
Fence Braces,
Fence Castings,
Hub Guard Straps,
Concrete Stop,
Bottom Chord,
Diagonals,
Suspenders,
Counters,
Laterals,
Sway Rods,
Portal Rods,
Pins-Drift-Cotter,
Rollers,
Pin Pilots,
Bolts:
  Lateral,
  Sway,
  Anchor,
  Floor,
Bolts:
  Patch,
  Tap,
  Construction,
  Hub Guard,
  Expansion,
  Scaffold,
  Track,
  Hook,
  U-Bolts,
Washers:
  Floor Bolt,
  Scaffold Bolt,
  Cotter Pin,
Lag Screws,
Rivets,
Nails and Spikes,
Sheet Lead,
Cast Risers,
Lateral Washers,
Sway Washers,
Name Plates,
Newel Posts,
Ornaments,
Name Plate Fastenings,
Ties,
Guard Rails,
Hub Guards,
Joists,
Floor Plank,
Spiking and Raising Pieces,
Paint,
Tools,
Coal,
Forges,
Crabs,
Blocks,
Ropes.

CHECK LIST—BUILDINGS.

Trusses:
  Rafters,
  Lower Chords,
  Ties,
  Struts,
  Suspenders,
Knee Braces,
Ventilators:
  Trusses,
  Braces,
  Frames,
  Circular,
Columns:
  Main,
  End,
  Crane,
  Clere Story,
  Lean To,
Purlins:
  Roof,
  Side,
  End,
  Gable,
Finish Angles,
Struts:
  Rafter,
  Bottom Chord,
  Eave,
  Sway,
  Crane,
Girders:
  Plate or Lattice,
  Crane,
Brackets:
  Floorbeams,
  Joist,
  Plates,
Wall Plates,
Bed Plates,
Separators,
Rods:
  Tie,
  Longitudinal Tie,
  Sway Ties,
  Sag Ties,
  Lat. Roof and Bot. chd.
Crane Rods,
Anchor Bolts,
Pins,
Cotters,
Bolts,
Rivets,
Stairs,
Railing,
Crane Track,
Bolts:
  Tap,
  Patch,
  U-Bolts,
Bolts:
  Hook,
  Louvre,
  Separator,
  Spiking Piece,
  Erection,
  Expansion,
Cotter Pin Washers,
Lag Screws,
Beam Anchors,
Purlin Anchors,
Wall Anchors,
Floor Ties,
Purlin Ties,
Ventilator Hooks,
Erection Sways,
Shutter Springs,
Hinge Bricks,
Iron Shutters,
Corrugated Iron,
Corr'gat'd Iron Floor Arches
Ridge Capping,
Flashing,
Clips,
Sheeting Rivets,
Gutters and Down Spouts,
Louvres,
Louvre Frames,
Corner Capping,
Cornice,
Gutter Hangers,
Corrugated Iron Rivets,
Clinch Rivets,
Nails,
Slaters' Cement,
Wire Rope,
Sash Trunnions,
Cleats,
Pulleys,
Rails,
Rail Clamps,
Rail Stops,
Sash Cord,
Hinges,
Wood Screws,
Templet for Set Bolts,
Castings,
Rolling Door Guides,
Rolling Door Track & Hangers,
Sash & Shutter Opening Gear,
Pipe Separators,
Windows,
Window Frames,
Doors,
Door Frames,
Name Plates,
Paint.

that he should work independenly of any of the squads, and report to the Head Draftsman. To have checking effective he should have liberty to change anything that does not suit his judgment. The amount of checking required will depend entirely on the care with which the work has been laid out and the drawing made. If laid out by an experienced man that knows his business very little checking will be required. It is false economy to think that the cost of making drawings will be decreased by employing cheap and inexperienced men. The drawings made by such men usually cost in actual wages paid out for making them about twice as much as though they had been made by higher-priced draftsmen who know their business. And this does not take into account the difference in the shop in working from well made and poorly made drawings. It is economy to have drawings made and checked in the very best possible way. Time spent in having them plain, clear and neatly made is saved a dozen times over in the shop and field before the work is completed.

In checking crooked or complicated joints, it is best for the checker to make a separate or independent lay out, to a large scale, locating all the rivets. He should take nothing for granted, but should check and investigate everything. In checking drawings and shop lists, the check lists on page 304 will be convenient. They may be reviewed to see if all matters have been considered.

CORRECTING DRAWINGS.

It should be a rule of the office that all drawings after being checked must be corrected at once, in preference to any other work. The draftsman must not simply take the checker's word for the proposed changes, but he must himself investigate the changes, and before any such changes are made the two must mutually agree. If changed without the draftsman's consent, then the drawing is really not checked at all. The proposed changes should be marked on the drawing with a blue pencil. This color will not print, is easily seen and is easily cleaned off afterwards with a rubber. Proposed new figures should be placed far enough away from the existing ones, that the new figures will not be effaced when erasing the ink ones. The draftsman should leave all blue marks on the tracing, and return the same to the checker for his final approval.

MARKING DRAWINGS.

There is much variation in reference to the marking of drawings. Two sets of marks are used—assembly marks and erection marks. Assembly marks are used for the convenience of men who assemble the material, ready for the riveters. It is generally the practice for the templet makers to put such marks on their blue prints when making the templets, and then to pass these prints on to the assembling gang. As these marks have no other use than that given above, this method is preferred, and will save much confusion on the drawings. But on the other hand some shops have all such marks put on the drawings in the drafting office. No two of these marks should be alike, unless the pieces are identical. It will be convenient to mark similar parts thus: A1, A2, A3, B1, B2, B3, etc.

Erection marks are to assist the field erection, and each separate shipping piece should have its own distinguishing mark. In such pieces as roof trusses that are shipped in pieces, the assembling marks may be the erection marks also.

LISTING.

In order to know just what material to bring into the shop, the workmen need to have a list of such material. It is usual to make such lists on printed forms, prepared just for this purpose. All such forms are printed on thin strong paper that will admit of blue printing. Each separate shipping piece is listed by itself. There are two columns for lengths, one for the finished length of the material, and the other for the length that was ordered. This last may contain a small excess for shearing off, or it may be a multiple length of the finished part.

The rivet and bolt list should then be made out. The size and length of all rivets and bolts are written down and a summary of these made. Forms for pins, eye bars, loop rods, clevises, etc., may be made out, and then a shipping list of the whole. This shipping list must contain the mark and description of every separate piece to be shipped to form the structure. Sections of truss work and the like can best be described by a line sketch. The width and length or any information that will assist the shipper in identifying the piece referred to should be given. Corrugated iron, flashing, bolts, rivets, clinch nails, gutters, conductors, spikes, railing, erection tools, lumber or any other material necessary for erection must be included. It is better that these lists should not be made till after the drawings are completed, for changes in the drawings will effect the lists to some extent. For highway bridges ship one keg of 60d. spikes for roadway of 20 ft. or less and 100 ft. in length, and one keg of 40d. spikes for the two sidewalks of the same bridge.

COPYING LISTS AND DRAWINGS.

A method of copying lists that is somewhat quicker than blue printing is to have these written in "printograph ink" and copied from the printograph block. A half dozen copies can in this way be made in four or five minutes that might require an hour or more to blue print.

ERECTION PLANS.

The erection plan is simply an outline on which to give the shipping or erection marks of all the various pieces. Bars and rods may be described by giving the size and length as well as the mark. The same applies to pins, stringers, etc. In the case of buildings it must show the location and length of all sheets of corrugated iron, flashing, etc. Bridge erection plans will show a section of the floor, with the size and length of lumber. It will specify which is the fixed and which the expansion end of the bridge. It will show the position of the name plate, and give directions in reference to the final painting, number of coats, color, etc. All such plans must give general dimensions. Bridges must show the packing of eye bars.

FILING OF LISTS AND DRAWINGS.

Drawings should be laid out flat in drawers and not rolled, as is the practice of some companies. These drawings may then be numbered consecutively, and a card index kept of the whole.

Lists may be kept in ordinary letter files in the order of the contract numbers. It is more convenient to keep drawings not in the order of their contract numbers, but all structures of a similar kind by themselves. That is to say, we would have one set of drawers for drawbridges, another for railway pin bridges, another for railway riveted bridges, another for steel cage buildings, another for mill buildings, etc. As each sheet will be numbered, and the various drawers numbered also, by referring to the card index any particular drawing may be found on a few minutes' notice.

AN AIR-RESISTANCE DYNAMOMETER CAR.

The Electric Railway Test Commission, appointed by the authorities of the Louisiana Purchase Exposition early in 1904, has for nearly a year past been conducting special investigations into unsolved problems of electric railroading. These investigations comprise studies of the alternating-current losses in steel rails; of the efficiency of various methods of braking and accelerating both city and suburban cars; of the energy consumption of cars in different kinds of service; and of the resistance offered by the air to the motion of cars at high speeds. Perhaps the most interesting part of the commission's work is in the last-named direction. A special dynamometer car, by which the total air resistance and its several components may be measured has been constructed and the test corps is now at work with it upon the lines of the Indiana Union Traction Company.

This work will complete the field work of the Commission. The complete results will be given to the public probably during the coming summer. However, a description of the dynamometer car, illustrated with some views kindly loaned us by Prof. H. H. Norris, of Cornell University, Superintendent of Tests for the Commission, may be appreciated at the present time.

The car (shown in Figs. 1 to 3 herewith) was built at the shops of the Indiana Union Traction Co. at Anderson, Ind., this company having cooperated heartily in the rather tedious work incident to experiments of this sort. It consists of a steel flat-car and an independent carbody which can roll freely on rails screwed to the flat-car floor. The car body has its main portion and vestibules separately mounted and connected to separate dynamometers, so that their several resistances may be determined.

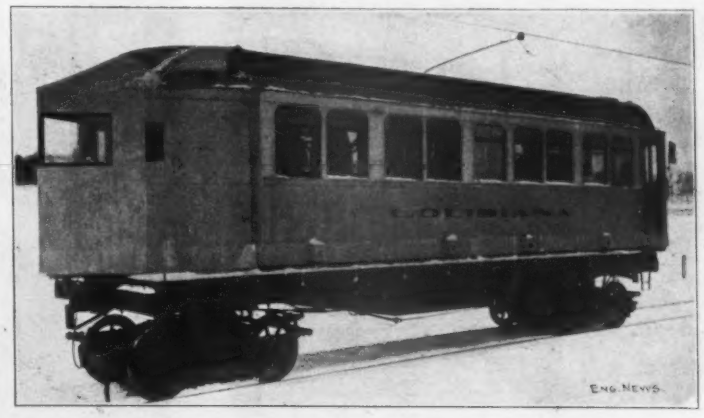

FIG. 1. AIR-RESISTANCE TEST CAR "LOUISIANA."
Constructed for the air-resistance tests of the Electric Railway Test Commission of the Louisiana Purchase Exposition.

The flat-car, loaned by the Pressed Steel Car Co., is fitted with two high-speed Baldwin trucks, placed at the disposal of the commission by the Indiana Union Traction Co. Four motors, rated at 75 HP. each, also loaned by the latter company, are fitted to the trucks. The underframe is provided with motor-driven compressor, governor and brake-cylinder, all furnished by the National Electric Co., and a hand-brake using Peacock brake drums supplied by the National Brake Co. As the car frame was raised considerably above its normal height by the arrangement used, heavy chains were fitted to prevent excessive motion of the frame with respect to the trucks, and special bumpers were constructed to prevent damage to other cars in coupling.

The car body mounted on this platform is 32 ft. long without vestibules, and was loaned by the J. G. Brill Company. Under its side sills are mounted eight Chapman double-ball bearings, and these carry four axles of 3 7-16 ins. diameter, 9 ft. long. Upon the axles are specially chilled wheels, 12 ins. in diameter, with ground treads. The rails are also ground where they come into contact with the wheels. By this method of mounting there is, for practical purposes, no friction between the body and the flat-car floor. The body is restrained from excessive motion by various effective safety devices. The pressure of the air upon the body is measured by means of scale beams, constructed for the tests by Fairbanks, Morse & Co. and loaned by them. The beams are supplied with dashpots. The weighing mechanism consists of the regular beam with weights and poise, and in addition a spring balance with dial is employed to render easier the manipulation of the machine.

A successful plan has been carried out on this car for the purpose of separating the head and rear resistances from the total. The vestibule is independent of the body but is carried therefrom by means of a link suspension. In order to guide the vestibule and to transmit the pressure to the weighing device a steel-trussed oak frame, attached to the vestibule, projects into the car a distance of 8 ft., being guided on all sides by small Chapman bearings. This method of sus-

pension has proven very satisfactory. In order to secure stability of the vestibule and body each of these is held against the scales by counterweights, the forces of which are transmitted through bell-cranks and levers, all equipped with knife-edge contacts.

In order to eliminate from the measurements all forces but those due to the air, the controllers are mounted upon iron stands carried upon the flat-car floor and projecting into the car body, thus removing the effect of stiffness in the controller cables, a serious matter in a car of this size. Similarly the trolley base is inside the car, carried upon the top of an oak post which projects upward from the flat car. No error is possible, therefore, from the resistance between trolley wheel and wire. While the forces mentioned are small in amount, the sensitiveness of the apparatus is such that the precautions taken are necessary.

The construction of the air resistance car was carried out by the test corps, which put in about three months in the actual detail work. This included the assembling of the equipment, the construction of the special brake rigging and other equipment with the exception of the heavy steel and wood work which was done by outside parties from the funds of the Commission. The corps also wired the car for a double-end controller arrangement, one controller of the Westinghouse "L4" type being loaned by the Traction Company, the other by the Westinghouse Electric & Mfg. Co., the latter also supplying a pair of circuit breakers and a large number of resistance grids for controlling the running speed of the cars.

Next to the weighing of the air resistances, the measurement of speed is most important. For this, two independent plans are employed. The test track, somewhat over 25,000 ft. in length, is divided into sections of 1,000 ft. each. The sections are marked by large signs plainly numbered. The instant of passing each sign is indicated on the graphical record of a General Electric recording ammeter which is also used for the current record. This ammeter records upon a strip of paper regular intervals of five seconds each. Upon this record is superimposed the time of passing each of the section signs, this being accomplished by closing a switch for an instant as each of these signs are passed. Thus the time of passing through a section of 1,000 ft. is accurately recorded. The second speed device consists of a small dynamo carried upon the truck frame and geared to the car axle by sprocket wheels and chain. This dynamo is an "Apple" igniter of the Dayton Electrical Mfg. Co. It has permanently magnetized field poles, but these also carry exciting coils through which the field current of the recording ammeter is also passed. As this current must be maintained accurately at a value of one ampere for current measuring purposes, it is admirably adapted for the purpose mentioned. The e. m. f. generated by the dynamo is read upon a Weston voltmeter specially arranged for this purpose. The e. m. f. at 60 miles per hour is about 7 volts. The readings are directly proportional to the speed. This apparatus has now been in operation for some weeks and has demonstrated its accuracy and convenience.

In addition to the speed measurements, accurate readings, at 5-second intervals, of the voltage across the motors is recorded, and the autographic current record is continuously checked by means of a direct-reading ammeter in the same circuit. The direction and velocity of the wind are also taken at frequent intervals, accurate anemometers having been supplied by Queen & Co. for the purpose.

The tests on the "Louisiana," as the air resistance car has been named, will continue until sufficient data are at hand to determine the resistance to the motion of different shapes of car front at all speeds reached by modern interurban cars up to seventy miles per hour, this limit being set by the line and motor capacities. A speed of 72 miles per hour has been reached for a short period.

During the past few days another important investigation has been completed by the use of a car exhibited by the Cincinnati Car Company at the Exposition. This car is supplied with the same motor equipment as the "Louisiana," but it has in addition the latest type of Westinghouse electro-pneumatic control. The tests made upon this car were designed to supplement those previously made and to supply important data, not only in regard to the control system, but having reference in general to heavy interurban car operation problems. An interesting feature of these tests was that all records were taken automatically, a special recording table having been constructed along the line of the experience gained at St. Louis. A wide strip of paper is carried by motor power across a glass table on opposite sides of which the observers are stationed with their instruments. Opposite each is a guide and pencil carriage the latter of which is operated by a cord carried over a drum attached to a point over the instrument needle. The observer simply follows the motion of the needle with his pointer and the result is recorded. The base line for each record is traced by a separate pencil carried on an electro-magnet through which passes all current from a time-marker recording five-second intervals, thus synchronizing all of the records. While somewhat similar to other recording apparatus in use, this equipment was designed independently and has some features of its own.

Fig. 2. Looking Toward Rear of Car.

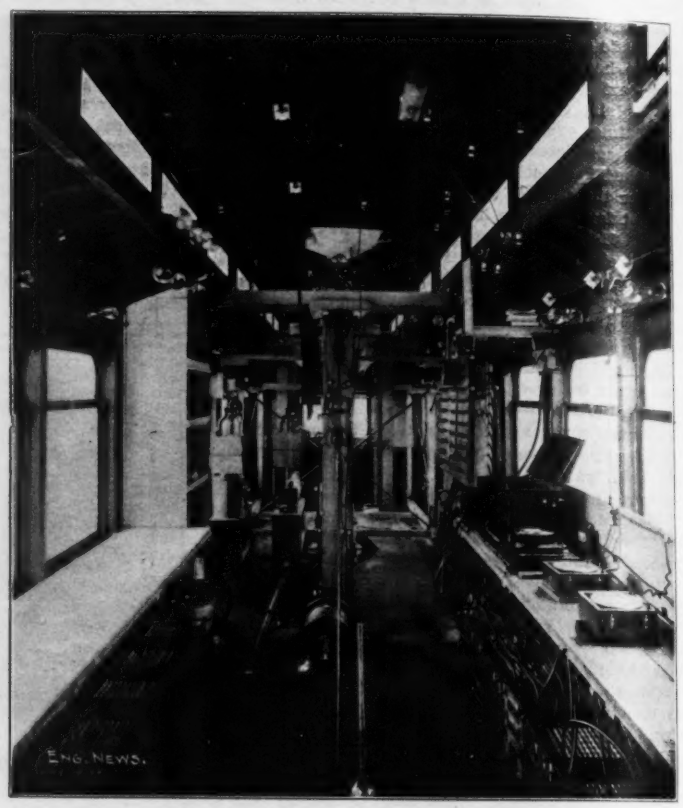

Fig. 3. Looking Toward Front of Car.

FIGS. 2 AND 3. INTERIOR VIEWS IN TEST CAR "LOUISIANA."

THE ERECTION OF 5,000-KW. ENGINE-DRIVEN ALTERNATORS.

By R. L. Wilson.*

The Rapid Transit Subway of New York City was opened to the public on Thursday, October 27, 1904. Much has been written descriptive of the various portions of this great enterprise; however, it may not be amiss to say something about the work of installing the 5,000-KW. generators which furnish the power for operating the trains.

The power house of the Interborough Rapid Transit Co. (the operating company of the Subway) is situated between 58th and 59th Sts., in the Borough of Manhattan, New York City, and extends from 11th Ave. to the North River. The generators installed therein which were built by the Westinghouse Electric & Manufacturing Co. of Pittsburg, Pa., are of 5,000 KW. nominal output each, run at 75 r. p. m. and deliver alternating current at 11,000 volts, three-phase. These machines are essentially the same as the eight units now in operation in the Manhattan (Elevated) Railway power-house at 74th St. and East River, New York City, and the remarks contained in the following may be taken to apply to both installations.

When the Manhattan Ry. power-house was planned, the 5,000-KW. generators then ordered

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FIG. 1. PRESSING THE HUB OF THE REVOLVING FIELD ON THE ENGINE-SHAFT; ERECTION OF THE INTERBOROUGH 5,000-KW. ALTERNATORS.

were the largest ever attempted, and these, together with those later built for the Subway power-house, still remain in dimensions and weight the largest electrical machines ever constructed. This distinction they bid fair to retain for some time, now that turbine apparatus has taken the field and monopolizes the attention of designing engineers. From the outset the design of these generators was governed by certain fixed conditions, the most important being the speed of the engine and the fly-wheel capacity to be provided in the rotating element of the generator, it having been previously determined to do away with the use of separate engine fly-wheels. These limitations led to the production of a revolving field or wheel 32 ft. in diameter and weighing approximately 332,000 lbs., the major portion of this weight being in the rim. The stationary part, or armature, to surround this field has a height of 42 ft. and a weight of 558,000 lbs.

The mechanical design and actual construction of such huge machines is a serious problem. After mature deliberation, it was decided to build the revolving field as a plate wheel, the rim being supported from the center by plates, instead of spokes or arms. This construction has obviously many advantages, but at first glance it presents a number of disadvantages, and its adoption seemed to cause considerable surprise among engineers, and at the start of installation elicited more or less pessimistic comment and criticism. It has, however, amply justified its originators, and has shown none of the predicted tendencies to vibration, and to run out of true.

It was feared at the outset that possibly the greatest objection to this type of construction would be the difficulties incident to assembling, and a brief description of the construction and methods adopted for installation may be of interest.

The revolving field consists of four essential parts, viz.: central hub, web plates, cast iron rim, and laminated steel rim, the latter forming also the field magnet poles.

The central portion consists of a hub weighing 20 tons, which is turned from a solid steel casting. This steel center has a bore of 37 ins. diameter, but with four different fits each 8 ins. long and an enlarged cored space 10 ins. long in the center. The four fits are provided to facilitate the pressing of the hub upon the engine shaft; and the allowance for pressure on each fit was 0.008 in. This in practice was found to be slightly excessive, and was reduced to 0.0065-0.007-in. With this latter allowance the pressure required to force the steel hub into position upon the engine shaft is from 500 to 600 tons.

The engine shafts, furnished by the Allis-Chalmers Co., are hollow, having a hole about 16 ins. in diameter running their entire length; the pressing is accomplished by the use of a hydraulic press designed especially for pressing crank disks upon engine shafts of this type. Heavy bolts are passed through the shaft, and are held at one end by heavy castings and nuts, while at the other end they support a specially constructed press consisting of a central casting carrying three hydraulic rams. The rams are set in a triangle, and press against filling-in pieces, which in turn are forced against the hub (see Fig. 1 herewith). The rams are actuated by a motor-driven pump. After the field center has been placed upon the engine shaft, it is firmly keyed to the latter.

The method of keying is rather unique, and was developed especially to facilitate erection after the first hub had been pressed into place. Two keys are provided, and are fitted into the shaft in diametrically opposite positions; one of them is a standard feather key, and the other is a feather which has the portion outside the shaft tapered on each side. The keyways of the hub are of different widths, the one being the correct size for the standard feather key, the other 2½ to 3 ins. wider. After the work of pressing is completed, two taper keys are fitted and driven in on each side of the special key and firmly held in place so as to preclude any possibility of their working out. The above construction insures a tight key on both sides, a condition almost impossible to produce by attempting to fit the keys in the shafts and cut the keyways in the hub exactly 180° apart.

As noted above, steel web-plates are attached to the hub and carry the intermediate cast iron rim. There are twelve of these plates, six on each side. The six plates form the entire circle, and are so installed that the plates of the two sides break joint. The sections of the plates are machined so as to leave a space about 1-32-in. between adjacent plates, in order to render assembling possible.

The web-plates, as well as the cast-iron rim and the steel hub, after being machined in the shop, are assembled (for the purpose of fitting) in a horizontal position, and hence without difficulty. It was found, however, to be an entirely different proposition to assemble these parts at destination in a vertical position around the engine shaft, and the following method was finally adopted.

The outer face of the central hub was drilled and tapped, and twelve special set screws with threads running their entire length were inserted at equidistant points. Over these were screwed lengths of heavy pipe, carrying special eye-bolts threaded into their outer ends with left hand thread. The set screws, pipes, etc., constituted tie-rods for holding the four cast-iron sections of the intermediate rim during erection. These ties are shown in position on the hub in Fig. 2. The two inner ribs of the cast-iron rim were drilled in such a way that, when the special eye-bolts were placed between the ribs, pins could be passed through the ribs and eye-bolts carried by the pipes. The four sections of the rim were put in place, beginning at the bottom section, and in this way was built up a species of tension wheel, which was self-supporting; the tie-rods, being fitted with right and left hand thread, enabled the rim to be adjusted to the proper circle. After this adjustment, the bolts and shrink links for holding together the sections of the intermediate rim were put in place. Fig. 3 shows the rim in position. It was then a comparatively easy matter to install the various sections of the web, beginning at the bottom and on both sides, the tie rods being taken out one by one, as the plates were fitted into place.

FIG. 2. TIE-RODS ON HUB TO HOLD CAST-IRON RIM DURING ERECTION.

Each of the twelve sections of the web is built up of two sections of heavy rolled steel plate, 1⅝ ins. and 1⅜ ins. in thickness, respectively, the thinner plate extending about half the distance from the hub to the cast iron rim and being riveted to the larger plate with heavy 2-in. rivets. In assembling the web-plates as above described, they are held in place by temporary stud bolts, 1½ ins. in diameter. For permanently holding the plates to the hub, 108 2¼-in. specially tapered stud bolts of varying lengths are used, arranged in three concentric circles, also thirty loose fitting

2-in. studs. The cast-iron rim is held permanently to the web plates by 144 2-in. specially tapered stud bolts, arranged in two circles. The taper studs are very carefully ground to gage, and are given a taper of 1-16-in. to the foot. Fig. 4 shows the field with some of the web-plates in place.

As it was absolutely essential that the taper bolts be tight, it was manifestly impossible to fit them before erection, hence the bolt holes in the plates, rim and hub were only roughly reamed in the shop. After the assembling of these parts at destination, using temporary bolts, all the holes are reamed to gage with special taper roughing and finishing reamers, and the permanent studs taken one at a time are driven in hard to a fit, and the nuts on both ends tightened. All the reaming at destination is done by hand, it being found more satisfactory and easier on the tools than any power device. In fitting the bolts, from ¼-in. to ⅛-in. is allowed for driving up, which driving is done by a 12 or 16-lb. sledge.

The true running of the rim radially is insured by a tongue and groove arrangement, tongues holes punched in the sheets, there being forty holes in each section. Through these holes are passed 1-in. cold rolled iron field studs, which, when tightened, compress the laminations and hold them in place. The nuts on these field studs are of a special disk type and fit into counterbores in the end plates, so that the whole field presents an even surface.

To build up the laminations, twenty end plate sections are first temporarily bolted to one side of the cast iron rim and a portion of the laminations built up against these, sufficient being put on to make up about 4 ins. in thickness, the joints in alternate layers of the laminations being carefully staggered. This first section of laminations is then pressed up hard against the end plates by the use of temporary studs and bolts, care being taken the while to keep the dove-tails driven back. While the pressure is still on, this section of laminations is fastened to the end plate, though not very tightly, so that it will retain its position after the pressure is removed. (Fig. 5). The above process of building on a section of the laminations and temporarily pressing it up is repeated

that side, and it is then necessary to press the rim back into a vertical position. This is done by the use of a 100-ton hydraulic jack, the jack being placed against the outer edge of the laminated rim, and the cast iron rim very carefully braced from the opposite side. The field is gone over in this maner several times, the laminations gradually forced over into a vertical position, and the field bolts again tightened up. It has been found possible, by this means, to produce a perfectly true running structure.

To complete the field, it now only remains to mount the field coils, which are held in place by heavy copper wedges in two sections, driven in between the poles from the opposite sides, and by brass coil supports bolted to the sides of the poles. Fig. 6 shows the completed field structure.

ERECTING THE ARMATURE.

The stationary element, or armature of these machines, is heavy and of rigid construction, and in the case of the Manhattan generators, is composed of six sections. The Subway units, on the other hand, have a seventh section in the form of a keystone at the top of the machine, this

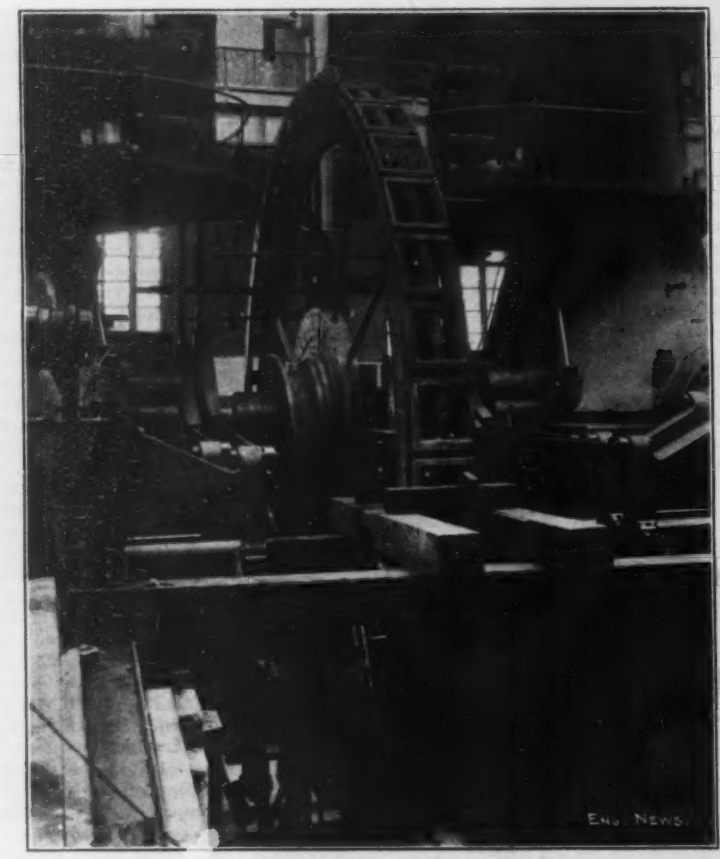


FIG. 3. CAST-IRON RIM OF REVOLVING FIELD ASSEMBLED ON HUB BY TIE-RODS.

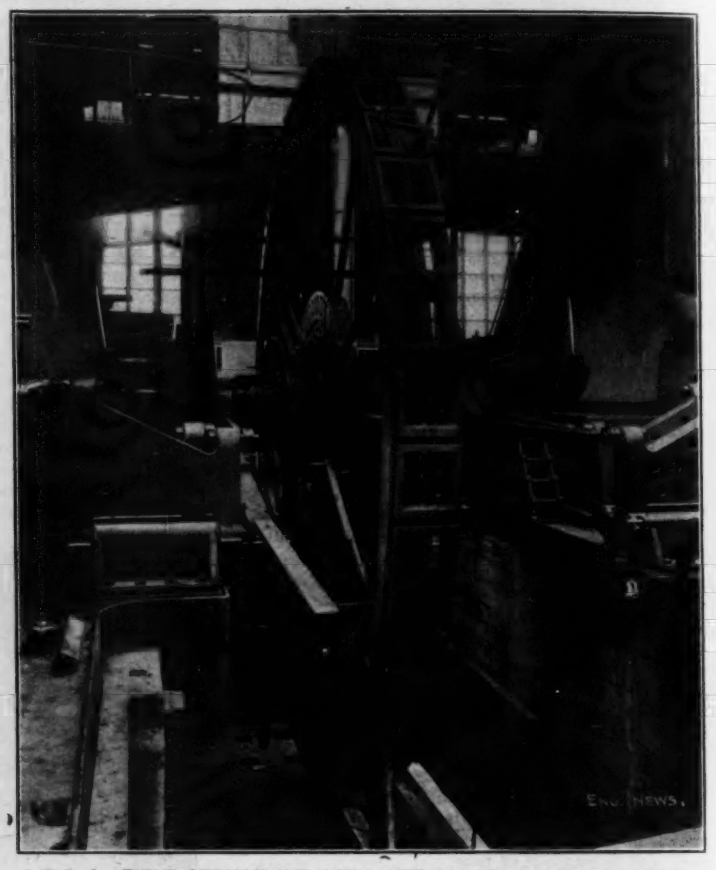


FIG. 4. FIELD STRUCTURE WITH WEB-PLATES PARTLY PLACED.

being turned on each side of the hub and rim which fit into grooves cut in the inner faces of the web plates. True lateral running of the rim is secured by the above-described method of erection, in connection with accurate machining, the stiffness of the plates, and the fact that the plates have a bearing surface on the hub of 22 ins. and on the rim of 12⅛ ins.

We come now to the building up of the laminated steel rim, which constitutes the real rim of the field, and also the field poles. This is built up of sheet steel punchings about 1-32-in. in thickness, accurately punched to shape, and of which twenty are required to complete one circle. Each sheet is punched with the holes through which pass the field studs, and carries two dovetails, the latter fitting into corresponding grooves machined at the proper intervals in the periphery of the cast iron rims. This dovetailed construction makes certain the correct radial position of the sheet steel punchings, and the whole assemblage of punchings is supported laterally by cast steel end plates 1½ ins. in thickness, of approximately the same shape and size as the punchings. Each end plate section is drilled to correspond with the

until the whole amount of laminated steel has been placed upon the field.

The successive pressing operations have been found necessary in order to prevent the laminations from buckling and obtaining a permanent set, which if allowed to take place will prevent the final trueing up of the field rim as a whole.

When all of the laminated steel, with ventilating ducts between, has been put on and pressed up as above, the end plates of the other side are put on and tightened up with temporary bolts, until the required thickness of finished field is obtained. The temporary bolts are then removed one at a time, and a drift forced through the punched holes of the laminations, in order to allow the insertion of the permanent 1-in. field studs. There are 800 of these latter in the entire field, and as the sheets are built up with joints broken, the whole completed structure constitutes a ring of great tensile strength and capable, in itself, of resisting all strains due to centrifugal force.

In the building up of this laminated rim, the sheets, etc., having all been put on from one side, the finished structure at first has a list toward

being provided to facilitate removal of a field coil when necessary. Considering, however, that in two years' operation of the Manhattan plant no occasion has arisen for the repair of a field coil, this provison is apt to be made use of but seldom.

The bed plate upon which the stationary element rests, is in two halves, each weighing approximately 20 tons. These are bolted and keyed together, and the whole carefully leveled and lined up, immediately after the engine shaft carrying the field center has been placed in its bearings. Before any weight is placed upon the bed plate, it is thoroughly grouted and filled in with concrete to a depth of eight or nine inches above the foundation.

The stationary armature is so shaped, fitted and bolted together as to insure the greatest rigidity in the frame as a whole. The steel punchings composing the laminated portion are built up in the various sections separately, being held radially by dove-tails, and laterally by heavy steel end plates. In building up, the ends of the punchings are allowed to project about ⅛-in. beyond the radial joint faces of the cast iron sections and, after they are tightened, the overhang

of the laminations is planed so that a continuous magnetic circuit is formed when the sections are assembled.

Unusual precautions were taken during the process of machining the armature sections to produce a truly circular air gap between the stationary and revolving parts of the generators. Cutting lines were laid off with the aid of a specially constructed transit, the circle of the bore being laid off upon the sections while they were in a horizontal position. After the abutting faces of the several parts were machined and before any further work was attempted, the whole was set up and a careful note taken of the amount the cast iron frame came down in a vertical direction, due to the spring of the castings. This deflection amounted in all cases to about ⅛-in. The sections were then taken down and assembled in a horizontal position for boring. In this setting the frame was pressed in by jacks an amount exactly equal to the deflection which had taken place when in a vertical position, thus securing a round bore in the completed machine.

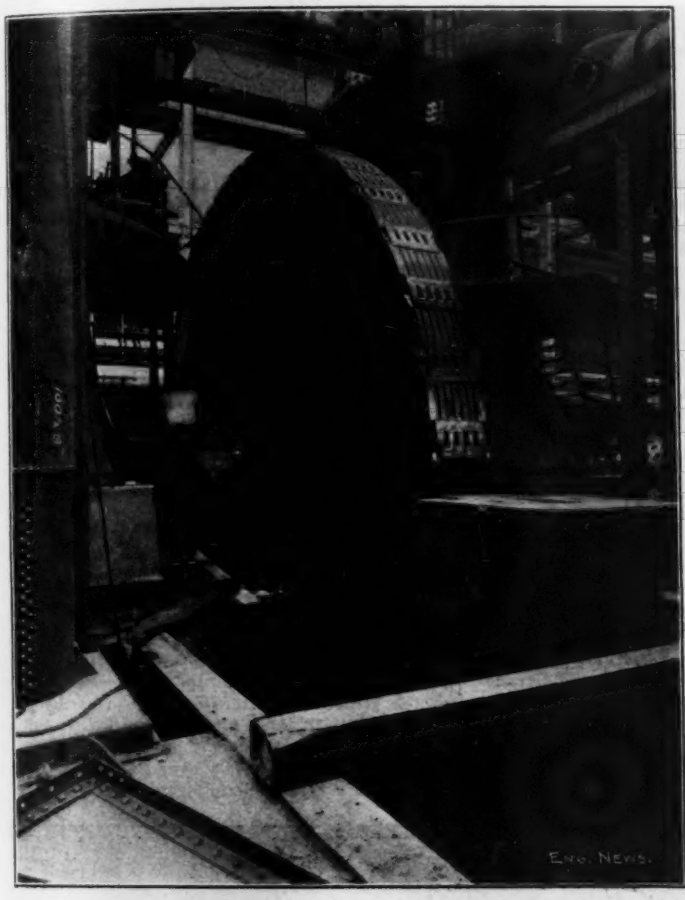


FIG. 5. PLACING THE FIELD-POLE PUNCHINGS.

FIG. 6. REVOLVING FIELD COMPLETED, WITH COILS AND WEDGES IN PLACE.

The boring was done with an especially constructed boring mill and the dovetailed slots were cut by portable slotters and millers; afterwards the laminations were built in as above described.

ARMATURE WINDING.

The stationary winding of both the Manhattan and Subway machines were put in at destination. They are arranged in three separate circuits, connected in star for delivering three-phase current at 11,000 volts. Provision is made in both instances for the grounding of the neutral point of the winding through a resistance, the latter limiting the possible flow of current to ground to about three times the full load current per phase. Thus far, both plants have been operated without the neutral being grounded, but this device is expected to eventually be of advantage in locating faults and minimizing the damages therefrom, and also in relieving the generating apparatus from strains due to breakdown of underground cables.

The Manhattan machines have 480 slots in the armature, and were wound with three bars per slot. As there are forty poles, the winding is necessarily arranged to give four slots per phase per pole, thus insuring a smooth wave form and adaptation to synchronous operation. The Subway generators have but 360 slots and a correspondingly greater number of bars per slot. The electrical characteristics, however, correspond closely with the earlier units.

The winding of the Manhattan generators is built up as follows: Three copper bars, comprising the three conductors in each slot, are separately insulated with rope paper, mica, and linen tape, which insulation is treated and dried after being put on the bars. The three separately insulated bars are then assembled and covered with 3½ turns of treated rope paper and mica held by linen tape, after which they are dipped in varnish and dried about twelve hours at 220° F. This operation is repeated three times, making four completed wrappings and treatings. Thus is formed a very efficient and one of the most durable insulations that can be devised. The three bars are separated at the ends and thoroughly tinned.

In winding, the insulated bars are placed in the slots and held firmly by grooved fiber wedges driven into slots over the top of the bars. To produce a continuous circuit, the bars are connected on either side of the machine by specially shaped connectors which are insulated in a manner similar to that of the bars, but not to the same extent. The individual groups of three bars are capable of safely withstanding a potential of 40,000 volts to ground, and the various sections of the winding during installation were subjected to a preliminary test of 30,000 volts to ground for several minutes. After the entire completion of the machines ready for operation, the armature coils were given an official breakdown test of 25,000 volts for thirty minutes. The finished winding presents a very attractive appearance, and is essentially adapted to ease in the making of repairs.

The winding of the Subway machines not only differs from the Manhattan in having fewer coils with a greater number of turns per coil, but the shape of the coils is also considerably modified. The individual conductors are insulated substantially in the same manner, but they are roughly of a "U" shape, several of them being assembled and insulated together to form an open coil, which is slipped into the slots from one side of the machine, the ends being then connected, soldered and insulated to complete the coil. This type of winding is not so attractive in appearance as the former and is slightly more difficult to repair, but it is somewhat more rigid and not only reduces the number of soldered connections by half, but also lends itself more readily to being braced against the strains due to accidental short circuits. The insulation upon the external portion of these coils differ from that of the Manhattan winding, in that it consists largely of oiled linen tape laid on with Sterling varnish.

The erection of the stationary parts or armatures of these generators presents no special problems, except such as are incident to the handling of very heavy and awkward shaped parts. In the case of the 74th St. power-house (Manhattan), the heavy parts were taken from the cars at Jersey City and placed upon lighters or floating derricks and then towed to the docks at 74th St., at which point they were lifted from the lighters and placed upon a flat car which ran into the power-house, under a 50-ton crane. At the 59th St. power-house (Subway) the loaded cars are run into the building and under the cranes, of which there are two, of 25 and 60 tons capacity, respectively. The winding of the stationary elements at the 74th St. power-house was done before the several sections were erected in position. At the 59th St. power-house, however, the whole machine is assembled before the winding is begun.

It may be interesting to note in conclusion the method adopted to start up one of these 5,000-KW. generators after it has been completed. The machine to be tried out is electrically tied in with another unit, through the auxiliary bus-bars which are, for the time being, not in use. Both engines are started simultaneously and, as they accelerate, the two generators naturally fall into step with each other, providing the phases are correct. If they are otherwise, manifestation of the same is given by the ammeters before any injury can result. This method has proven very

satisfactory and is considered to be much more practical in starting units of this size for the first time, than is the method whereby dependence is put upon potential transformers, lamps, synchroscopes, etc., the connections to which are prone to go wrong.

REINFORCED CONCRETE MEDICAL LABORATORY: BROOKLYN NAVY YARD.

A good example of the application of reinforced concrete to buildings of moderate size and simple form is furnished by the new medical laboratory building recently constructed on the hospital grounds of the Brooklyn, New York, navy yard. This building is in plan a rectangle 160 ft. long and 60 ft. wide; it has four floors, including the basement floor and is covered with a hip roof provided with a skylight along the ridge. The walls are of brick, but the floors, the interior columns and the roof are of reinforced concrete. The same material was also used for the partitions and stairs. Structurally the feature of greatest novelty is the roof construction, and this presents several points of interest. The floors and their supports and the partitions are merely notable in typifying simple straightforward designing of such details in reinforced concrete.

COLUMNS AND FOOTINGS.—Two longitudinal rows of columns divide the building transversely into three bays, two side bays of 20 ft. span and a center bay of 24 ft. span. The columns in each row are set 16 ft. apart on centers and the distance from the center of the endmost column of each row to the end wall is 20 ft. Each column reaches from the basement footing to the roof girders or rafters. The basement was excavated to hardpan, 10 ft. below grade, and the footings were constructed directly on this material. With an assumed safe loading of 3 tons per square foot, the end columns of each row required a footing 7½ ft. square, and the intermediate columns required footings 7 ft. 3 ins. square. The details of one of the smaller footings are shown by Fig. 1.

The columns were designed for an assumed floor load of 275 lbs. per sq. ft., an assumed roof, load of 100 lbs. per sq. ft., and an assumed working stress of 20,000 lbs. per sq. in. in steel for tension and compression and of 500 lbs. in concrete for compression. These assumptions gave columns 23 ins. square for the basement, 19 ins. sq. for the first story, 15 ins. square for the second story, and 10 ins. sq. for the attic. Each column is reinforced by a vertical bar in each corner; they are tied together at intervals of 12 ins. by ¼-in. bar hoops. At the top, where the girder comes onto it, the column is bracketed out primarily to shorten the spans of the girders, but also to improve the appearance of the ceiling. The hoops reinforcing the brackets are shown by Fig. 2; the same drawing shows the sleeve connection for abutting vertical bars. These sleeve joints were filled with grout.

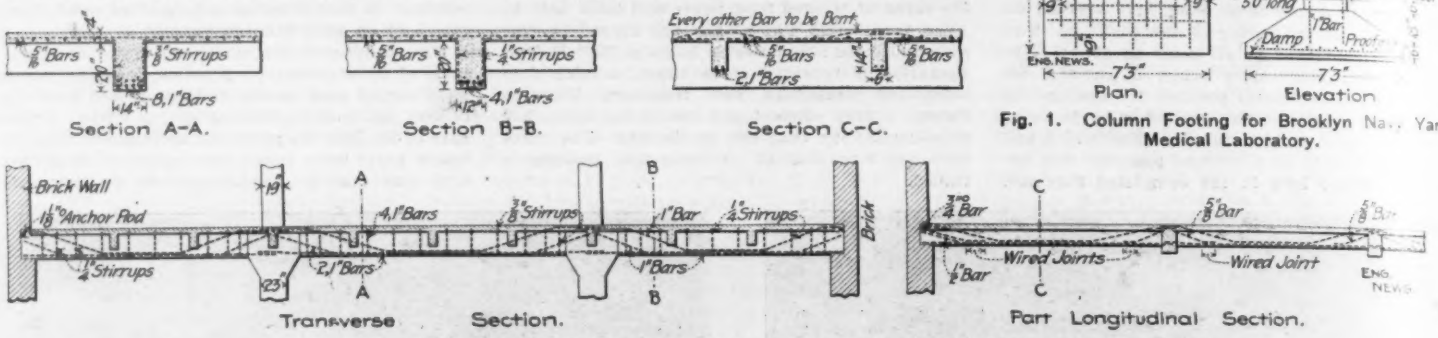


FIG. 3. DETAILS OF FLOORS FOR BROOKLYN NAVY YARD MEDICAL LABORATORY.

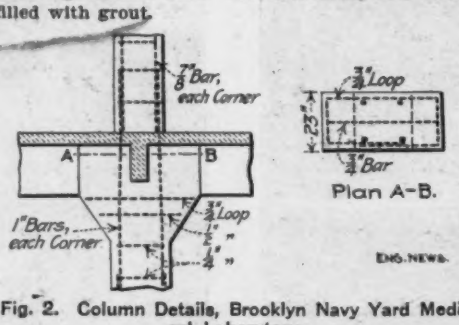


Fig. 2. Column Details, Brooklyn Navy Yard Medical Laboratory.

FLOOR CONSTRUCTION.—The floors are slab and girder construction. The girders extend transversely across the building and each is carried by the side walls and two intermediate columns. Between the girders are beams spaced 5½ ft. apart, and on these beams rest the floor slabs. The beams at the ends of the building have clear spans of 17½ ft., and all intermediate beams have spans of 15 ft. The girders have three spans, two end spans of 20 ft. and a center span of 24 ft., which are reduced by the column brackets to clear spans of 17 ft. and 21 ft. The drawings of Fig. 3 show the construction of the girders, beams and floor slabs. About the only points that need be noted further are the form of stirrup and the use of "catinary" bars in the floor slab, and the wall anchors. The design of the stirrup is such that it holds the bars the proper distance above the beam bottom by having its top hooked to hang on the floor slab forms. The wall anchors consist of rods built into the brickwork; the girder and beam rods are hooked over this anchor, as shown. The floor slabs are finished with 3 ins. of concrete and 1 in. of mortar troweled to a smooth surface. The view, Fig. 4, shows the appearance of the finished floor and ceiling construction.

ROOF CONSTRUCTION.—The roof construction shown in detail by the drawings of Fig. 5 presents several interesting features. It is in the first place a pitched roof, making an angle of 30° with the horizontal, and, secondly, it is constructed of cinder concrete instead of stone concrete in order to reduce its weight. The layout of the roof corresponds to that of the floors and the reinforcement is similar except that the area of steel required is greatly reduced. A skylight opening 16 ft. 4 ins. wide and 79 ft. long was provided in the peak, and for this reason only two of the girders or rafters continue over the peak of the roof. In these girders there is, in addition to the usual reinforcement, in the upper part, a bar reaching continuously over the peak from the wall plates. The remaining four girders do not

Fig. 1. Column Footing for Brooklyn Navy Yard Medical Laboratory.

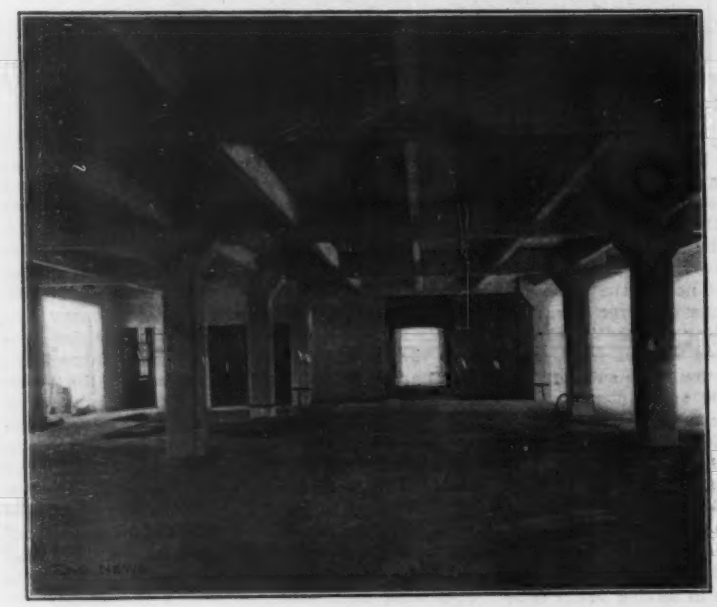


FIG. 4. INTERIOR VIEW OF NAVY YARD LABORATORY, SHOWING CEILINGS AND FLOORS.

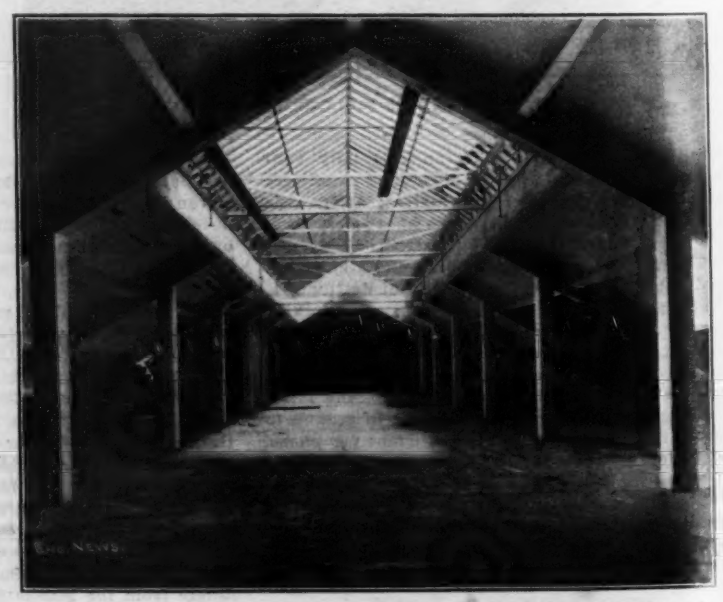


FIG. 6. VIEW ON ATTIC FLOOR SHOWING ROOF CONSTRUCTION OF BROOKLYN NAVY YARD MEDICAL LABORATORY.

extend to the peak, but reach only to the skylight curb on each side, their upper ends projecting 4 ft. 6 ins. beyond the columns and being reinforced as cantilevers. This construction is shown in detail by the drawings of Fig. 5 and also by the view Fig. 6.

Referring to Fig. 6, there will be seen two girders spanning the skylight opening. These are designed to carry the sheaves for the elevators and are made of stone concrete 8 ins. wide and 14 ins. deep, with three ½-in. tension bars and two 5-16-in. compression bars to make up for the deficiency of concrete in compression. One of the tension bars is bent up at the ends and carried over the supports and there is, as an additional resistance to shear, a 5-16-in. hoop spaced every 12 ins. throughout the beam. The beams were designed for two concentric loads of 2,000 lbs. each, spaced 2 ft. from each support.

In laying the cinder concrete on the roof incline the mixture was made rather dry, but no other precautions were found necessary to keep it in place. A slate roof covers the concrete slab. To insure an even surface to receive the slate, a finish coating of cement and sand mortar was first tried, but was found to be too hard for a nail to penetrate. A mortar mixture of one part cement, two parts sand and four parts cinder screenings was applied about ¼-in. thick and was found to be quite satisfactory. The nails from the slate penetrated this coating quite easily and held well when in place.

PARTITIONS AND STAIRS.—All partitions inclosing shafts and staircases were made of reinforced concrete. They were generally 3 ins. thick, but those inclosing the stairs were made 4 ins. thick. Both thicknesses were reinforced by 5-16-in. bars spaced 12 ins. on centers in both directions. The stairs consist of slabs having a plain bottom and tops notched to form the treads and rims. They are all in straight runs, with an intermediate landing between floors. The reinforcement consists of ¼-in. bars reaching from floor to landing, and spaced 6 ins. apart and of ¼-in. bars reaching transversely from partition to partition and spaced 12 ins. apart. The finish of the stairs consists of a 1-16-in. coat of mortar highly colored with lamp black and worked onto the concrete with trowels.

MATERIALS AND CONSTRUCTION.—The concrete for the columns was a 1-2-3 trap-rock mixture; that for the roof was a 1-3-5 cinder mixture, and that for the remainder of the work was a 1-3-5 half trap-rock and half gravel mixture. The trap-rock was broken to ¾-in. size, and the cement was Lehigh Portland.

The forms used in constructing the building were the standard column, girder and slab forms used by the contractors and are clearly shown by the views Figs. 7 and 8. The forms for each floor were erected in three days, and generally three days were required to place the concrete so that one floor was completed each week.

The concrete-steel work was all designed and built by the Turner Construction Co., of New York City. Mr. Ernest Flagg, of New York City, was the architect. All work was done under the direct supervision of the Department of Medicine, Washington, D. C., represented by Dr. Harman. The laboratory is to be used for the storage and testing of medicines and provisions for the Navy Yard Hospital.

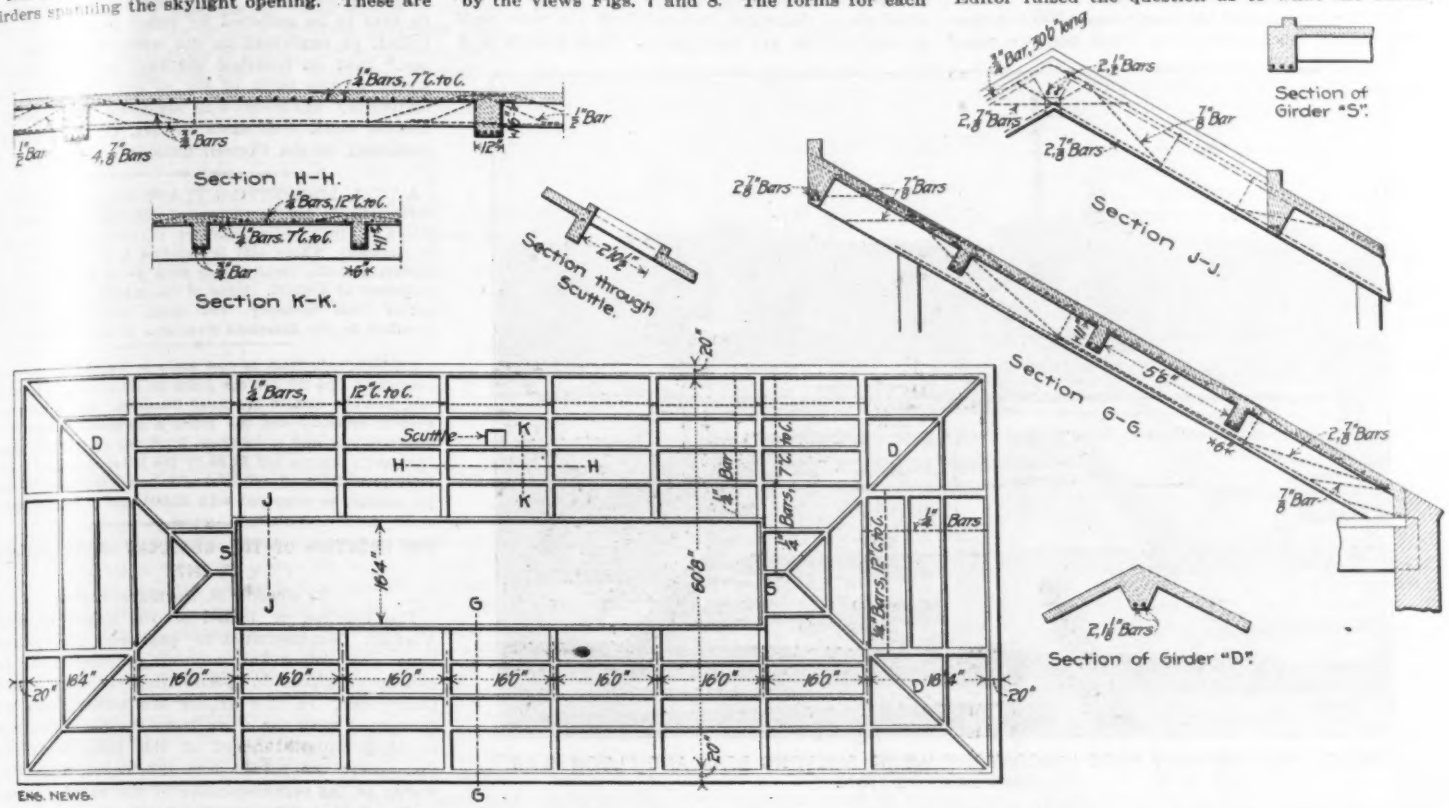


FIG. 5. DETAILS OF HIP ROOF IN REINFORCED CONCRETE, BROOKLYN NAVY YARD MEDICAL LABORATORY.

THE SOFTENING OF HARD WATER BY HEATING IT UNDER PRESSURE.

By Nicholas Knight.*

Commenting on the writer's paper in Engineering News of August 18, 1904, on softening hard water by boiling under normal pressure, the Editor raised the question as to what the effect might be of continued boiling under high pressure, so as to reproduce the conditions that exist in closed feed water heaters where the water is heated under pressure to precipitate the solids in solution. To study this question the apparatus shown herewith was devised and constructed by Frank L. Hann, to whom we make grateful acknowledgment.

a is a safety valve, b a thermometer extending into the boiler 3½ ins. by means

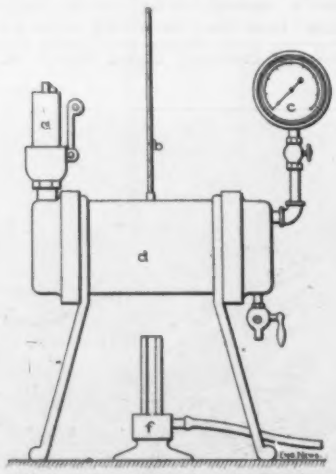
*Professor of Chemistry, Cornell College, Mt. Vernon, Iowa.

FIG. 7. VIEW OF NAVY YARD LABORATORY WORK, SHOWING COLUMN AND GIRDER FORMS IN PLACE.

of a tube closed at the lower end; c is a steam gage for noting the pressure; d, body of the boiler, made from 5-in. heavy gas pipe, closed at each end with heavy caps; e is a stop-cock for removing the water; f is a triple Bunsen burner. The capacity of the boiler is about 1,800 c. c. Before using the apparatus, it was subjected to a hydraulic test of 200 lbs. pressure.

There was placed in the apparatus 1,200 c. c. water. Heat was applied with triple burners, until the steam gage indicated a pressure of 90 to 100 lbs. It was not necessary to use a thermometer, as according to Regnault's tables of the tension of aqueous vapors the temperature would be about 156° C. This temperature was maintained with a triple burner for thirty minutes. The apparatus and contents were allowed to cool, and the water was drawn off into a glass-stoppered bottle, 500 c. c. were filtered and evaporated to dryness in a weighed platinum vessel of 125 c. c. capacity. The residue was heated at 110° to constant weight. The numbers express the amounts of the various substances in 100,000 parts of the water.

Total solids in platinum vessel	16.52
$CaSo_4$	3.43
$CaCo_3$	3.90
$MgCo_3$	4.61
SiO_2	1.70
Fe_2O_3	0.18
NaCl and KCl	2.70
	16.52



Sketch of Laboratory Apparatus for Testing Amount of Precipitation of Solids Due to Heating Water Under Pressure.

The analysis of the raw water drawn at the same time resulted as follows:

Total solids in platinum dish	30.58
$CaSo_4$	3.43
$CaCo_3$	12.65
$MgCo_3$	10.69
SiO_2	1.70
Fe_2O_3	0.18
NaCl and KCl	2.70
	31.35

For purposes of comparison the results of the analysis of the water pumped from the same well in April, 1904, are here given. This sample was boiled vigorously with a triple burner for twenty minutes at normal pressure.

Total solids in platinum dish	19.18
$CaSo_4$	0.98
$CaCo_3$	4.25
$MgCo_3$	8.52
SiO_2	1.66
Fe_2O_3	0.27
NaCl and KCl	2.34
	18.02

The analysis of the raw water drawn at the same time as the foregoing resulted as follows:

Total solids in the platinum dish	28.86
$CaSo_4$	0.98
$CaCo_3$	12.47
$MgCo_3$	10.42
SiO_2	2.12
Fe_2O_3	0.26
NaCl and KCl	2.34
	28.59

The difference between the raw water analyzed in April, 1904, and again in October of the same year, is mainly due to an increased amount of calcium sulphate at the latter date. The other constituents remained quite constant.

These investigations resulted in the discovery that the well 330 ft. in depth from which the water was taken receives a considerable surface drainage at certain times in the year. This causes the solids in solution to vary in amount.

Comparing the effect of boiling the water under normal pressure with boiling it under a pressure of six or seven atmospheres, it is seen that the precipitation of calcium carbonate is substantially the same in each case, while the precipitation of magnesium carbonate is increased by the difference between 8.52 and 4.61 or 3.91 by the greater pressure. Boiling for twenty minutes at the normal pressure removes 44% of the temporary hardness, that is, the calcium and magnesium carbonates. At the increased pressure, 63.5% is removed. The water therefore can not be said to be softened by either process. It was found, as explained in the writer's previous paper,* that on treating the raw water with lime water in the ratio of six to one, 71.4% of the temporary hardness was removed. The experimental work was done by Mr. C. G. Hildredge, Assistant in the Cornell College laboratory.

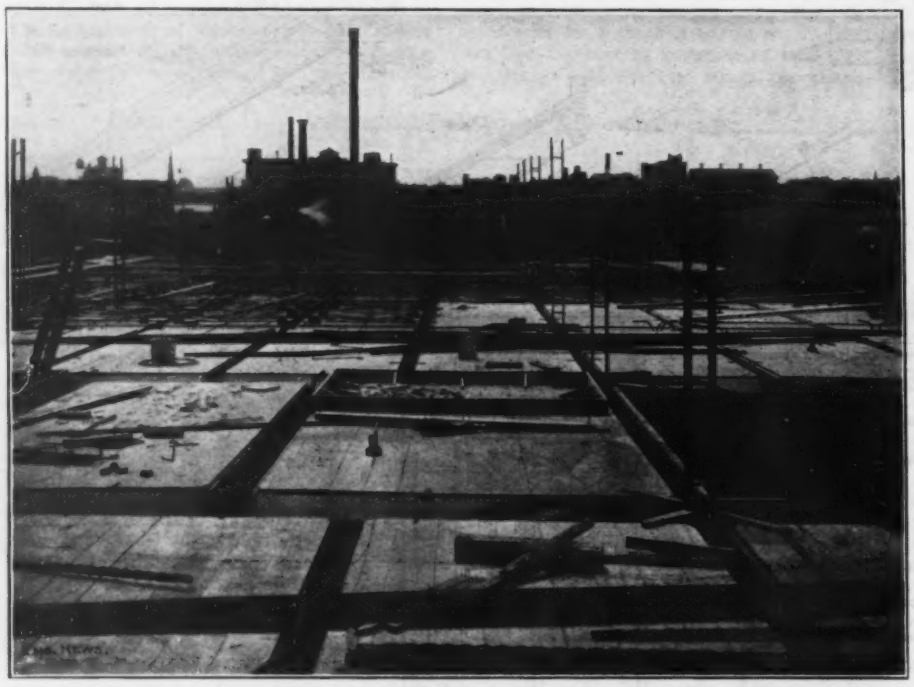


FIG. 8. VIEW OF NAVY YARD LABORATORY WORK, SHOWING BEAM AND FLOOR SLAB FORMS IN POSITION.

A COAL BRIQUETTING PLANT is to be installed at Gallup, N. M., for the purpose of utilizing lignite from the mines at that place. Samples of this coal were sent to Germany, where coal briquetting is a commercial industry, and the results were such as to warrant the installation of a plant. Some of the machinery will be imported from Germany. The plant will be owned and operated by the American Fuel Co., of Denver, Colo.

ARTIFICIAL SILK is now made in Europe by two large companies, the Société des Soies de Chardonnet de Besancon, and the Société des Soies Viscoses. The former is a French company and the latter a Belgian. The cost of production is said to be about $2.90 per kg. by the former company's process and $1.35 by the latter company's. The total production of artificial silk now reaches 4,000 tons per annum, as compared with 30,000 tons of animal silk.

THE ERECTION OF THE KENTUCKY RIVER VIADUCT IN 1877.

By Joseph H. Springer, Sr.†

The erection in 1876-7 of the Kentucky River Viaduct demonstrated to engineers for the first time the important advantage offered by the cantilever girder in permitting erection without falseworks. In this article the writer, who was connected with the work from the beginning, first as Shop Superintendent of the Edge Moor Iron Co., where the bridge was fabricated, and afterwards as the representative of the same company in the field during erection, proposes to outline briefly the methods adopted in constructing this historical structure. It is believed that the data presented are accurate and reliable; the illustrations are copied from the original drawings made by the Baltimore Bridge Co., under the direct supervision of Mr. C. Shaler Smith, M. Am. Soc. C. E., its President and Chief Engineer.

The Kentucky River Viaduct carries the Cincinnati Southern Ry. across the deep gorge of the Kentucky River at a point 103 miles south of Cincinnati, O. It occupies the site selected by John A. Roebling in the early fifties for a railway suspension bridge, of 1,236 ft. span, and, in fact, the towers built by Roebling for his suspension bridge form part of the later structure. Plans were received from a number of engineers, and the one finally adopted was that submitted by the Baltimore Bridge Co. The iron was rolled by the Pencoyd Iron Works, and was fabricated by the Edge Moor Iron Co., in the years 1875-6. The first piece of iron was placed in position in the bridge in October, 1876, and the bridge was opened for traffic in the spring of 1877. The following are the principal dimensions of the structure as completed:

Length between abutments	1,138 ft.
Length of each span	375 ft.
Depth of truss	37 ft. 3 ins.
Width of c. to c. of trusses	18 ft.
Height of rail above low water	275 ft.

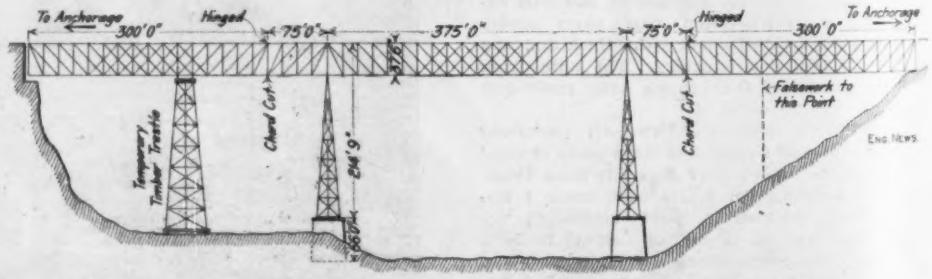


FIG. 1. ELEVATION OF KENTUCKY RIVER BRIDGE FROM ERECTION DRAWINGS.

*Engineering News, Aug. 18, 1904, page 149.
†Galt House, Louisville, Ky.

Total height of ironwork	214 ft.
Total height of masonry	71½ ft.
Stone pier at base	119¼ × 42 ft.
Towers at base	71½ × 28 ft.
Towers at top	18 × 1 ft.
Iron in spans	2,855,379 lbs.
Iron in towers	798,901 lbs.
Cubic yards of masonry	12,935
Cubic yards of excavation	14,665
Flood rise of river	57 ft.

Fig. 1 is a diagram elevation of the bridge redrawn from the original erection drawings. The axis of the bridge is almost due north and south. At the north end the cliff is nearly vertical; at the south end the cliff had a slope of about 45°. The old suspension bridge towers shown in the illustration were set about 30 ft. back from the edge of the cliff on each side, and if memory is not at fault they were about 12 × 10 × 70 ft. They are built of stone masonry, and are founded on solid rock. While at the bridge recently the writer conversed with an old resident who saw the towers built and who stated that the foundation courses were surfaced to the bed rock and anchored by 1 in. wrought iron dowel pins. The stones in the towers were about 10 and 12 ins. thick and about 3 × 4 ft. in lateral dimensions. The stones were laid in cement mortar, and each stone was fastened by five 1-in. wrought-iron dowels.

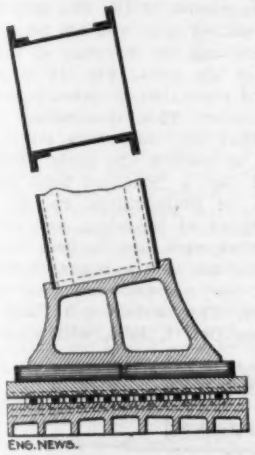


Fig. 6. Detail of Bottom of Tower Leg, Kentucky River Bridge.

In constructing the viaduct, Mr. Smith utilized these masonry towers as anchorages, as shown by the sketch Fig. 2. The anchorage proper consists of 12 × 12 in. by 12-ft. oak timbers, built up solid and drift-bolted together, and it spans the space between the two towers as indicated by the drawing. The bolts passing through the timber are 4 ins. in diameter, and are of hammered iron. One end is threaded, and provided with a cast-steel nut, and the other end is provided with a forged eye. Five links of eye-bars connect the anchor bolts with the end of the top chord of each truss. The eye-bars are 7 × 1¼ ins. in section, and, except those in the link nearest the trusses, are about 10 ft. long. These bars are the anchor bars that were built into the masonry for the old suspension bridge. Mr. Smith had several of them tested at Edge Moor.

The trusses were spaced 18 ft. apart, and Fig. 3 shows the end members of one of them. As will be seen, the truss rests on a base casting set on a shelf cut in the solid ledge rock of the bluff. A ¼-in. sheet of lead was placed between the casting and the rock. The cells in the casting were filled with coal tar. It will be noted that screw-jacks were inserted between the ends of the bottom chords and the rock wall at the rear of the base casting. These jacks had an 8-in. screw, and were made entirely of cast steel. The end posts sit in rabbits milled across the edges of the plates

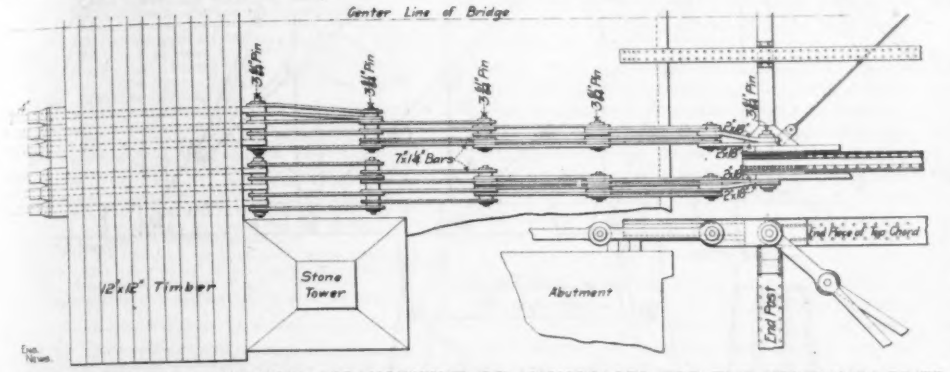


FIG. 2. SKETCHES SHOWING ARRANGEMENT OF ANCHORAGES FOR THE KENTUCKY RIVER BRIDGE.

bolsters on the pedestal castings. The first panel lengths of the bottom chords were then inserted in the bolsters, and the end pin was placed and fastened. Meanwhile, the outer free ends of the chord pieces were held up by wire ropes from windlasses on the traveler. The end posts were then set up, and the floor beam fastened between them. The next step was to assemble the several members held by the top chord end pin and complete the connection. The second panel posts were then erected, and the top and bottom chord and diagonal connections completed in the manner now familiar to engineers. When all parts were in place the bridge was lined up by the engineer and brought into position by placing the lateral and sway bracing. All the connections were then riveted up completely before the traveler was shifted ahead for the erection of the second panel. The part played in the field by the Edge Moor Iron Co. was to do all the riveting.

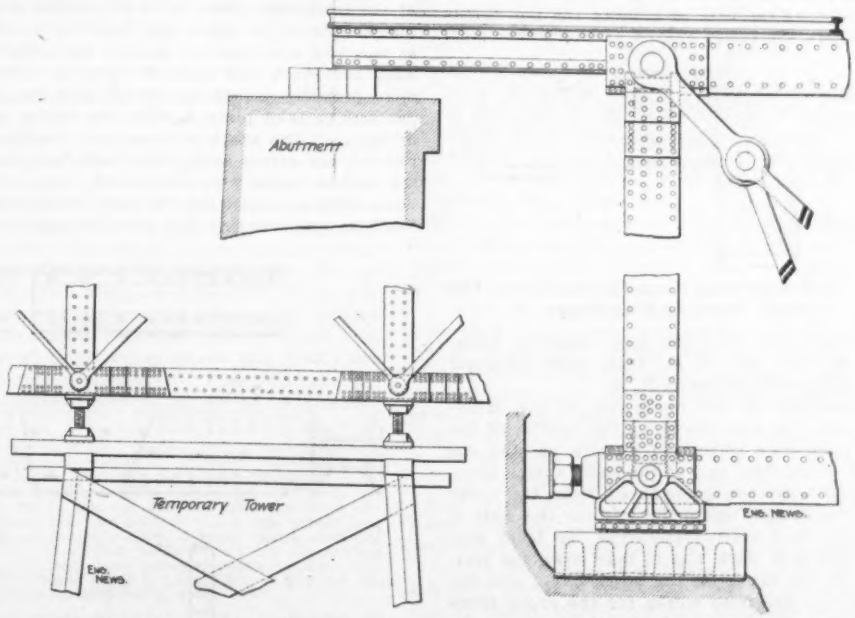


Fig. 4. Sketch Showing Arrangement of Seating Trusses on Top of Temporary Tower.

Fig 3. Sketch Showing End Post and Bearings at North End of Kentucky River Bridge.

The erection of the second panel and all of the succeeding panels was performed by duplicating the processes just described until the completion of the eleventh panel brought the ironwork to rest on the temporary towers. Up to this point the entire weight of the hanging arm of the bridge was held by the anchor chains. The trusses were brought to rest on screw jacks set on top of the temporary tower, as shown by Fig. 4. These jacks were the same in dimensions and construction as those at the chord ends. Their location is shown by the sketch Fig. 4.

As stated above, the temporary tower was constructed of wood. It was 50 ft. square at the base and 18 ft. square at the top, and consisted of four legs braced together in all directions. The tower legs each consisted of four 9 × 9 in. × 16-ft. timbers, laid solid and so as to break joints.

While the portion of the bridge just described was being erected, work was also in progress on the north tower. This work was comparatively simple. Fig. 5 gives skeleton elevations of the towers, showing the calculated stresses and the sectional areas of the several members. Fig. 6 shows the construction at the bottoms of the tower legs; it will be noticed that there are two sets of rollers under each leg. The legs themselves are made up of plates and angles to form a box section; they were fabricated in lengths or sections of one story each. The joints were formed by riveting four inside angles to the bottom of each section. These angles project about 24 ins., and drop inside the section below, to which they are attached by tap bolts. A saddle casting of steel connects the legs on each side of the bridge at their tops, and receives the pin on which the truss rests. This saddle casting was assembled and accurately fitted at the shops. The drawings of Fig. 7 show the construction at the top of the tower.

It will be noted from Fig. 1 that in that portion of the span between the temporary tower and the iron tower, the diagonal tension members of the trusses slope toward the abutment, and consequently give no support for erection purposes. To erect this section of the trusses use was therefore made of false diagonals. These were 4 × ⅞-in. iron bars, with end pinholes, and were slipped over the pins outside of the permanent diagonals. Two bars were used on each side of the chords, the pins being extended to provide for their use. With these false bars erection proceeded exactly as described for the preceding section of the span. When the span had been landed on the iron tower, the temporary erecting bars were removed.

Referring again to Fig. 1, it will be noted that the top chord is marked "hinged," and the bottom chord is marked "cut" at the fourth panel points, counting inshore from the iron towers. The temporary and the permanent construction at these points deserves mention. Considering first to the top chord hinge, it should be mentioned that the top chord piece A 17, reading from the north end of the bridge, is not riveted to splice plates to connect it to the succeeding chord piece A 16, as is done at all the other top chord panel points. Instead, a box made of channels and plates and

about 4 ft. long was slipped half its length inside chord piece A 17, and riveted to it. The projecting end of this box was slipped inside chord piece A 16, so as to have about ¼ in. play on all four sides. At the joint a space of ¾ in. was left between chord pieces A 16 and A 17, as shown

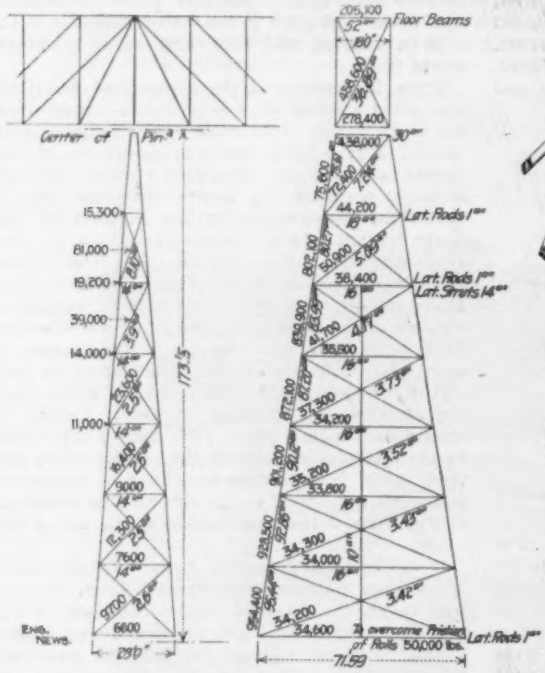


Fig. 5. Skeleton Elevations of Iron Towers Showing Stresses and Sections, Kentucky River Bridge.

by Fig. 8. The pin in A 16 passes through the extended end of A 17. Turning now to the bottom chord connection at this point, it will be seen from Fig. 9 that the construction is similar to that of the top chord joint described, but during erection the sliding joint was firmly riveted to both chord pieces C 16 and C 17, the rivets being cut out after the bridge was completed. It should be noted that the idea of hinging the top chords and cutting the lower chords at the points indi-

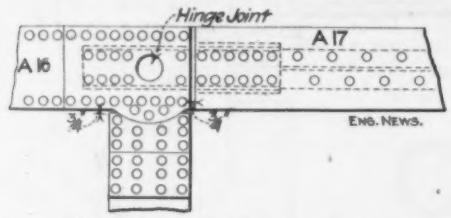


Fig. 8. Sketch Showing Hinge Construction in Top Chords, Kentucky River Bridge.

cated originated with the late Gustave Bouscaren, M. Am. Soc. C. E., then Chief Engineer of the Cincinnati Southern R. R.

The erection of the remainder of the trusswork from the iron tower to the middle of the center span was performed exactly as was the erection of the first half of the shore span. Erection work was then commenced from the south end of the bridge, where the iron for this half of the bridge had been transferred by team and ferry. The first work was to take down the temporary timber tower on the north bank, and use the material for false works for the south shore span as far as the eleventh panel point from the

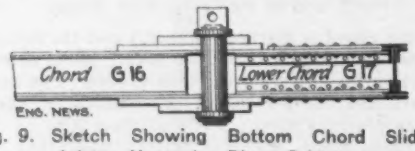


Fig. 9. Sketch Showing Bottom Chord Sliding Joints, Kentucky River Bridge.

end post. The remaining nine panels to the iron tower were erected by using false diagonals exactly as was the corresponding portion of the north shore span. From the iron tower to the middle of the river span the method of erection was the same as for the north half of the same span.

When the final panel members for the south half of the bridge had been put in place, it was found that the two halves of the bridge did not

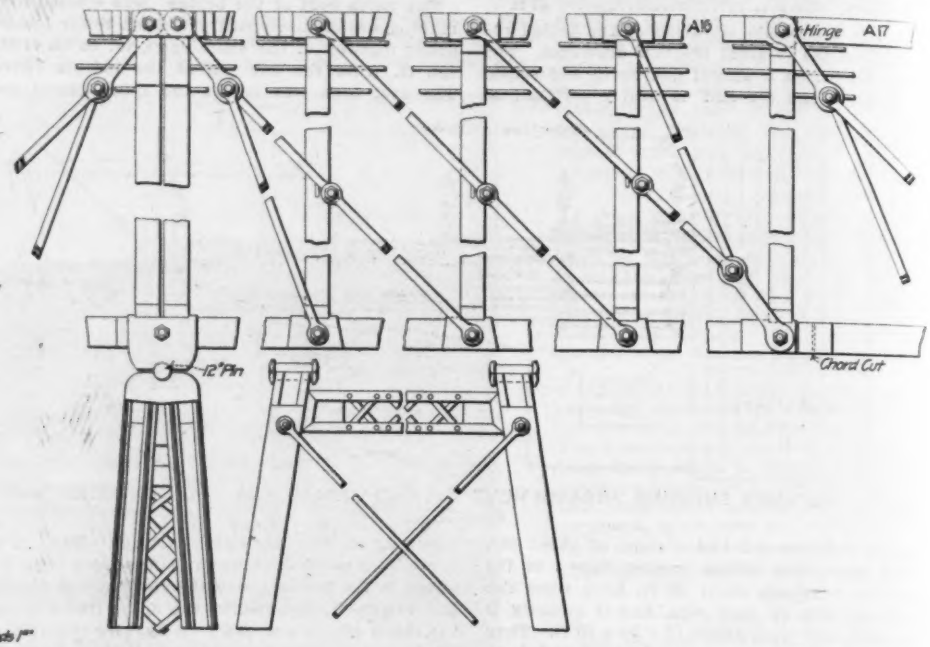


FIG. 7. SKETCHES OF TOWER BEARINGS AND TRUSSES, KENTUCKY RIVER BRIDGE.

meet. The top and bottom chords did not come together within a distance of 6 ins., and the tension bars could not be connected. This was in the spring of 1877, and the middle of the day was very warm; observation showed that the north half of the structure crept southward enough during the warm hours to loosen the jack screws shown in Fig. 3. It was decided to take advantage of this movement to close the connection. The jack screws that had been used on the top of the temporary tower were set behind the bottom chords at the south end, and the top chords at this end were blocked against the rock. This fixed the south end against creeping inshore or more properly caused the lengthening due to expansion to take place toward the center of the bridge. At the north end, as the structure expanded, the screw jacks were tightened up, and the anchor chains were slacked off. These operations were continued for six days, when daylight could be seen through the rivet holes of the adjoining chords at the center. Drift pins were then inserted, and the connection completed.

In closing, a few words of credit are due the Edge Moor Iron Co. for the character of the workmanship on this bridge. As has been said, all the material was iron, and it was rolled at the Pencoyd Iron Works, of Philadelphia, Pa. The material was inspected at the mills by Mr. Howard Bates. The specifications were drawn by Mr. Gustave Bouscaren, and were very rigid. Every rivet-hole in the structure was reamed, and so far as the writer knows, this was the first reamed bridge to be built in the United States. All riveted and forged members were run out of the shop and placed on skids. Iron rods ⅝ in. square, made for laying off the work from standards made by Brown & Sharpe, were laid on the members, so that temperature of the two would become the same. A skilled man and his helper laid off all the members, and the workmen at the machine shop followed his lines. Fig. 10 is a drawing of lower chord piece C 9; all other lower chord pieces were similar. This illustration is introduced to show that the ends were milled, and the top rabbited to receive the posts. The pin-holes were bored by a machine built by William Sellers & Co., of Philadelphia, Pa. The chords were all assembled at the shop, and the splices reamed. The work went into the field, and was erected without the use of a hammer, chisel or file, and without an accident—not even a mashed foot or finger. The writer left Philadelphia for the field on Oct. 1, 1876, with eight gangs of riveters, and started them all back home in good health on March 1, 1877. He has had a great many years' experience in bridge work, and is free to say that he never saw better workmanship than was performed on the Kentucky River Bridge, built nearly 30 years ago.

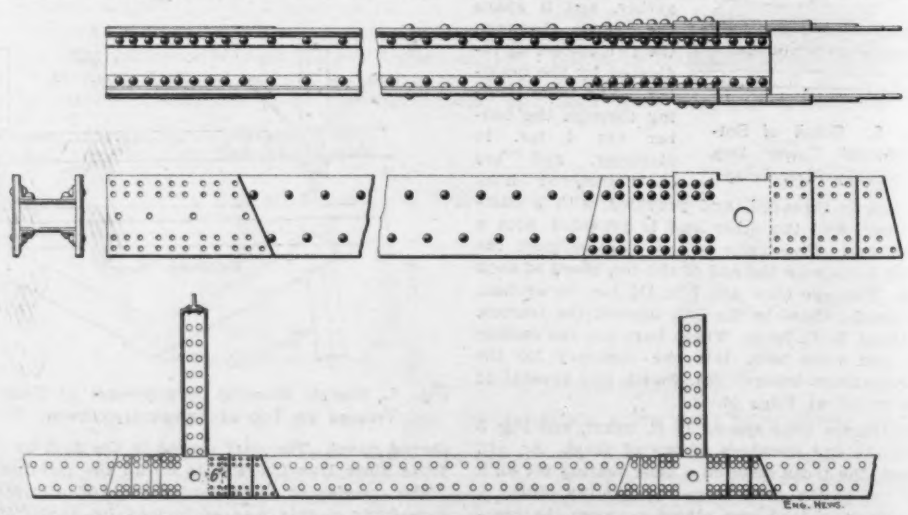


FIG. 10. DETAILS OF TYPICAL LENGTH OF BOTTOM CHORD, KENTUCKY RIVER BRIDGE.

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Our offer in our last issue of prizes for the best papers on concrete block construction has brought to us the letter printed below from the publishers of "The Cement Age," the journal edited by Mr. Robert W. Lesley, Assoc. Am. Soc. C. E., who is to act as one of the jury in the award of the prizes:

Editor Engineering News:

Sir: We beg to extend to you our heartiest congratulations on your exceedingly valuable plan of offering a prize for the best paper on the manufacture of concrete blocks and their use in building construction. We agree with you that this is a vitally important subject to the cement and concrete interests and that it has not so far received the attention which is its due from the engineering press. We cannot conceive of anything likely to produce so much good to the concrete block business as the series of papers which are bound to result from your offer.

To the end of making our appreciation of this work substantial we would be most happy to combine with you in this work and we will agree to increase the first prize which you offer by $100 and the second prize by $25, making a total first prize of $250 and a second of $100.

That the papers may have the widest publicity we would suggest that they be published in both the Engineering News and the "Cement Age."

Yours very truly, Bruce & Johnston,
Publishers "The Cement Age."

New York, March 16, 1905.

We have accepted the above offer, and competitors for the prizes, therefore, have now the incentive of a first prize of $250 and a second prize of $100.

We have also decided upon an important change in the conditions of the offer announced last week. It has been represented to us that a number of the professors and post-graduate students in the engineering schools may desire to take part in this competition, but would be unable to give the necessary time to the work before the summer vacation. Others desiring to take part in the competition but able to devote comparatively little time to the work, may not be able to prepare papers and have them ready by the date set last week (May 31). It has been decided, therefore, to postpone the date of closing the competition to July 31, giving competitors over four months in which to work.

With these changes the formal announcement of the competition becomes as follows:

The sum of $350 is offered in prizes for the best papers on "The Manufacture of Concrete Blocks and their Use in Building Construction." The sum of $250 will be awarded as a first prize and $100 as a second prize.*

The merit of the papers will be judged chiefly from the standpoint of their practical usefulness to an engineer who proposes to establish a local business in the manufacture of concrete blocks.

The length of the paper should be not less than 5,000 words and not more than 10,000 words. It may be accompanied by any drawings or photographs which the author deems necessary for its illustration.

All manuscripts must be typewritten and must be received at the New York office of this company not later than July 31, 1905. They must be signed with some nom de plume and accompanied by a sealed envelope bearing on its outside the nom de plume and inside the name and address of the author of the paper. Manuscripts and all accompanying matter should be sent fully prepaid, by express or registered mail, since their receipt by us cannot be acknowledged in the ordinary manner. They should be marked on the outside of the wrapper, "For the Concrete Block Prize Competition."

As soon as possible after the close of the competition, the manuscripts will be examined by the editors of Engineering News, and from the whole number offered, the five best manuscripts will be selected for submission to a jury consisting of Messrs. Robert W. Lesley, Past President of the American Cement Manufacturers' Association; Richard L. Humphrey, President of the Cement Users' Association, and Prof. Edgar Marburg, Secretary of the American Society of Testing Materials. In case the editors experience difficulty in making the primary selection, a larger number of manuscripts than five may be submitted to this jury.

As soon as a selection is made by the jury, the sealed envelopes will be opened and public announcement made of the result of the competition. The prize articles will be published in Engineering News and in the "Cement Age." The Engineering News Publishing Co. will have the right also to publish any other articles submitted in the competition and not awarded a prize, or any portions of such articles, paying the author for the matter so used at our regular rates for contributed articles. The right is also reserved to copyright the prize articles or others accepted for publication; and the matter may be later published in book form.

*The sum of $225 will be paid to the winners by the Engineering News Pub. Co., which has instituted the competition, and $125 by the publishers of the "Cement Age."

A curious illustration of the difference between an idea as it first presents itself to the mind and its aspect after testing with the aid of a few arithmetical computations is furnished by a letter received a few days ago, in which the writer desired us to call attention to the advantages of hollow staybolts to improve the combustion in locomotive fireboxes. He pointed out that in some of the large modern locomotives the ashpan damper openings are very small in comparison to the size of the grate, and combustion suffers from lack of air. While hollow staybolts are generally used on account of the warning which they give when fractured, this correspondent thought their use was also advantageous as an aid to combustion. He said:

With the dampers of a modern locomotive contracted, how is perfect combustion to be attained? By staying the firebox with hollow stays with an inside diameter of ⅛-in. and not over 3-16-in. You cannot get sufficient air through the grates, and you dare not have the air in excessive volumes over the firebed, but to the extent that you can get air through 1,000 or more hollow staybolts with ⅛-in. holes, whether sufficient or not for perfect combustion, you will have enough oxygen by its union with the combustible gases in the firebox to pay for the hollow staybolts several times over.

We have no doubt at all of the good faith of our correspondent; but let us figure a little on his proposition. Suppose we have 1,000 hollow staybolts with ⅛-in. openings in the sides of a locomotive firebox. Their combined cross-section will be

$$\frac{\pi}{4}\left(\frac{1}{8}\right)^2 \times 1000 = 12 \text{ sq. ins. nearly.}$$

The velocity of air through a ⅛-in. diameter tube some 5 ins. long is bound to be pretty low, probably not over 1,000 ft. per minute; but to give the idea credit for all there can possibly be in it suppose we assume the velocity at 5,000 ft. per minute. Then the total volume of air supplied through the 1,000 hollow staybolts will be $5{,}000 \times \frac{1}{12} = 416$ cu. ft. per minute, or about 32 lbs., or enough air for the combustion of something over a pound of coal per minute. There are good, sound arguments for the use of hollow staybolts; but the promotion of combustion in the firebox is not among them.

Some very foolish newspaper reports have been circulated recently to the effect that the new high-pressure water supply system for New York City is so badly designed that it would be worthless for actual use in fighting fire.

As the best method of replying to these published criticisms, Commissioner Oakley has had Acting Chief Engineer De Varona prepare a description of the design of the plant, and through the courtesy of the Department we are able to present a full abstract of this report in this issue. Inasmuch as no such large high-pressure system of fire mains has ever been installed in any city, the designs of the New York system is of much interest and well worth placing on record.

It is, we believe, highly unfortunate that the newspapers persist in calling the new system a *salt* water supply. As designed by Mr. Hill and later by Mr. De Varona, the entire pipe system will contain fresh water and only fresh water.

There will be emergency suction openings at the pumping stations by which water from the East or North Rivers may be drawn in wherever, in case of a great conflagration, the supply from the fresh water mains may prove insufficient; but such a thing ought not to occur once in ten years or twenty years.

Under such conditions the high pressure supply should be an entire success; but the presence of salt water in the system at any other time than an actual emergency in a conflagration ought by all means to be avoided.

Engineers know from actual experience in hundreds of cases that cast-iron exposed to salt water suffers rapid corrosion. Just how rapid this corrosion will be cannot be known in advance. It may be on the average that the pipe would be good for ten years or twenty years or even thirty years; but the important point to bear in mind is that it is not the *average* life of the pipe, but life of the most rapidly corroded section that will fix the life of the whole system. Salt water corrosion is not by any means uniform. Some irons waste away much more rapidly than others. Some lengths fail by pitting.

Only a few weeks ago we printed some striking figures regarding the cost of digging up and repairing underground piping. We refer to them at this time only to illustrate what folly it would be to lay an expensive system of cast-iron fire protection mains, and then fill them with salt water, which will rapidly destroy them, make them unreliable for use in an emergency and at an early date make necessary frequent digging up of the streets for repairs.

As we said above, the new high-pressure fire mains have been designed for the use of fresh water; but there has been hitched on to them a lot of street washing hydrants which we very much fear may at some future time be made an excuse for introducing salt water into the system.

In our opinion the cleaning of streets by flushing with a hose is much too doubtful a proposition to justify the city of New York undertaking to complicate the new high-pressure fire protection system in the way that is now proposed.

As was pointed out in these columns a year ago, with the average grades of New York sewers, cleaning streets with a hose simply means that a large proportion of the dirt on the surface must be laboriously hoisted from sewer catch-basins instead of shovelled directly into carts. Not until the favorable opinion of a body of expert engineers is secured, ought New York to adopt the policy of flushing its streets with water instead of sweeping them.

Of course the amateur defenders of the street flushing idea quote the practise of Paris in sup-

port of their proposition; but they overlook the difference between the sewers of Paris and those of New York.

The Paris sewers—as we need hardly remind our readers—are really underground subways, and there is a most elaborate plant and force for cleaning out the deposits which result from the copious washing of the streets above. Because street flushing works well in Paris it does not at all follow that it would work well in New York.

Then as to the water for this street flushing. As pointed out above, the salt water from the rivers can only be used by submitting the whole fire main system to rapid corrosion, with all that that involves. The fresh potable water brought from the Croton or the Catskills is too valuable to use for washing streets, at least under ordinary conditions. Of course there are occasional periods during the hot weather months, averaging perhaps a dozen days in the course of a year, when flushing the streets is worth much more than the mere cleaning effected. At such times —unless a water famine were impending at the time—there is no reason why the existing fresh water supply should not be used; and it would in fact be far preferable from a sanitary standpoint to street flushing with water drawn from any point on the East or North Rivers.

CONCRETE AS A PRESERVATIVE OF STEEL FROM RUST.

Is steel embedded in concrete perfectly and permanently protected from corrosion? A correspondent whose letter we publish in another column raises this question anew and suggests that the inquiry is one that we should take up. We agree with this opinion, not because we doubt the sufficiency of available evidence, but because the idea should not get abroad that designers in reinforced concrete have been laboring in the dark in this particular. On the contrary, there are few questions connected with reinforced concrete work in which the evidence is so definite and conclusive.

The fact that Portland cement is a highly alkaline substance is regarded by many as proof that it should be a good material to preserve iron from rust. There is, of course, good chemical reasoning for this opinion. Rust is caused by the presence of acid gases and moisture in the air. Cement being alkaline, should neutralize the acid solutions and prevent the iron from being attacked by them. The trouble with this argument is that experience has shown that iron embedded in concrete does in some cases corrode badly despite the alkaline character of its covering. Some explanation is, therefore, necessary for this deviation of experience from theory before we are warranted in pinning our faith to concrete as a preservative of steel from rust. This explanation seems to be found in the fact that where rust has been noted, the protecting envelope has either been fissured or else not everywhere in close contact with the metal.

In support of the last statement we may quote the evidence of the tests of Prof. Charles L. Norton, of the Massachusetts Institute of Technology. These tests were fully described in Engineering News of Oct. 23, 1902, and Jan. 14, 1904. Two sets of tests were made by Prof. Norton. In one set several hundred briquettes were made of various compositions of mortar and concrete, with pieces of steel embedded in them. These briquettes were subjected to air, steam and carbon dioxide, air and steam, and air and carbon dioxide. At the end of three weeks' exposure it was found that neat Portland cement had furnished a perfect protection in all cases. The corrosion of the steel in the mortar and concrete specimens was always at a point where a void existed in the concrete or where a rusted cinder had lain. In every case where the concrete or mortar had been mixed wet, and the surface of the steel had thus been coated with a thin layer of grout no rust spots occurred.

The second set of tests made by Prof. Norton was the same as the first, except that rusted steel was used instead of clean steel. After from one to three months in tanks of steam and carbon dioxide, specimens which had been in all stages of corrosion before being imbedded in concrete had not suffered any sensible change in weight or size except when the concrete had been poorly applied.

These series of tests, so far as they go, are certainly conclusive. They prove beyond doubt that when steel is enveloped in concrete, which is at every point in close contact with the metal and is without fissures, it will not rust, at least in a few months, even when subjected to the fierce attack of steam and carbon dioxide. Safety for a short period of time against a concentrated attack surely warrants us in assuming that the far less violent forces of the ordinary atmospheric air could be resisted for a much longer period of time. For actual long time tests, however, we must go to the records of experience.

Practical examples of this preservation of iron by concrete for many years are not wanting. There are also occasional instances where the evidence apparently indicates that rust will take place. In all of these cases the evidence has been secured by dismantling old structures, and in most of them the observation of the condition of the embedded steel was an incidental matter. The mere fact that the steel had rusted or had not, was noted, but no careful study was made of the character and condition of the concrete envelope or of the conditions which might or might not have influenced the chances of corrosion. It is because of this that the few isolated cases of rusting that have been instanced are not so impressive as they would otherwise be. We are quite justified in assuming that these cases represent instances in which the protecting envelope was faulty, while the examples which showed no rust represented instances in which the concrete envelope was intact and in close contact with the metal.

It is hardly necessary to cite specific examples of steel being preserved for a long period of years by being embedded in concrete. The text-books and treatises on cements and concrete are full of them. It may be noted, however, that there are well authenticated cases of steel being removed from concrete after 15 to 20 years in just as good condition as it was the day it was embedded. We have, moreover, the knowledge that scores of reinforced concrete structures built ten, fifteen and twenty years ago, are still standing and doing their work with no indication of weakness or disruption because of rusting steel. With this evidence at hand on every side, the fear that our works of reinforced concrete are slowly being destroyed by the rusting of the steel elements seems rather far fetched.

Notwithstanding all that has been said in proof of concrete being a preservative of steel, it is plain that it is this only when proper precautions are taken in applying the protecting envelope. The concrete must be brought into intimate contact with the metal at every point. In fact it would be better if each bar could be surrounded with neat cement. Something of this nature is done when the concrete is mixed wet and well rammed or joggled into place; the cement flushes the surface of the metal and covers it with a thin coating of grout. The same end may be accomplished by dipping the bars into a bath of grout before they are placed, but it is usually impracticable to do this in commercial work. The more certain protection of the steel from rust is one of the principal arguments for using a wet concrete and a concrete rich in cement.

LETTERS TO THE EDITOR.

Laying Pipe Under Water by Cutting the Supporting Cords.

Sir: The article in your number of Mar. 2, on laying a subaqueous pipe, and describing how a lucky accident much facilitated the work, leads me to say that the late John F. Ward once laid a long stretch of flexible joint pipe in the same way. The size, I think, was 6 ins., and he supported each length by a cord or rope strong enough to support one length, but not strong enough to support two. When all was ready, one cord was cut, the rest broke successively, and the pipe was quickly and successfully laid. Mr. Ward was the inventor of the flexible pipe joint which bears his name, and which is described in Trautwine's Engineer's Pocket-Book.

Very truly yours, H. W. Brinckerhoff.

45 Broadway, New York City, Mar. 11, 1905.

A Remarkable Record for an American Manufacturer and American Railways.

Sir: In order to enable the Mexican Light & Power Co. to effect temporary repairs to their generating station in the City of Mexico, which was recently partially destroyed by fire, two express shipments were made from the Schenectady works of the General Electric Co. on Feb. 8 and 11, which were remarkable both for their size and for their prompt despatch.

Telegraphic advices were received by the Foreign Department on Monday, Feb. 6, stating that a large quantity of switchboard material would be required to enable the plant to resume operation, although at the time the full extent of the damage was not known. As a result of further telegrams and consultations by telephone with the New York representatives of the customer, details of the order were settled Tuesday morning, and on Wednesday, Feb. 8, the second day from the receipt of information of the trouble, an express shipment of 30,000 lbs. of switchboard instruments, switches and supplies left the Schenectady factory for Mexico City.

The shipment constituted a complete switchboard equipment for a 4,000-KW. power station, and to collect and despatch the material in this almost incredibly short time taxed every resource of the commercial, engineering and transportation departments of the company. While most of the instruments and switches were available at Schenectady, it was necessary to obtain instrument transformers by express from Lynn, and four large rheostats for generators of German make had to be entirely built from data telegraphed from Mexico. In addition a large quantity of wire and cable, which could not be supplied from the Schenectady stock, had to be borrowed from an installation which the General Electric Co. was carrying out in New York City.

The transportation of the heavy reels of wire and cable through New York City for shipment to Schenectady was a task of great difficulty on account of the almost impassable condition of the streets following a severe snow storm. In handling the shipment from Schenectady, special arrangements were made with the railway companies to obviate trans-shipments in passing from one system to another, and especially in crossing the Mexican frontier, and in addition a special messenger traveled with the car the entire distance to see that no delays occurred at junction points.

The shipment reached Mexico City on Tuesday, Feb. 14, thus placing in the hands of the customer, within seven days from receipt of the first news of the disaster and from a factory over thirty-seven hundred miles away, a complete outfit of the new material necessary to restore the interrupted lighting and power service.

The fire also destroyed two engine-driven sets, imperatively demanding the immediate installation of two 500-KW. Curtis steam turbine-generators that were on order at the time, and one of which was due to arrive by freight in a few days. The second turbine had just been loaded on a freight car at the Schenectady factory, but the urgent need of the machine decided the customer to authorize its shipment by express.

Of this shipment the turbine proper, as boxed, weighed 27,000 lbs. and occupied a space 8 ft. high by 8 ft. wide by 9½ ft. long. The doors of the ordinary express car would not admit the entrance of a package of these dimensions, but a special car having large doors was secured and by stripping the boxing to a minimum the loading was effected. The generator and other parts brought the weight up to nearly 43,000 lbs., making one of the heaviest single express shipments ever made. The total weight of the entire shipments was 73,000 lbs., the express rate on which was over $8,200.

F. H. Gale.

44 Broad St., New York City, March 15, 1905.

Does Concrete Protect Imbedded Steel from Rust?

Sir: As a constant reader of Engineering News, an article by H. G. Tyrrell in your issue of Jan. 5, on the failure of the Charleston Suspension Bridge, has a peculiar interest for me in one of its aspects that may possibly be overlooked by some readers. This is its important connection with the whole subject of reinforced concrete, now so largely advertised and recommended in the professional papers all over the world, though this connection may at first sight appear somewhat far-fetched.

I do not wish to go into the subject of the failure from rust of the individual wires forming the cable that failed, although this question is one of equal interest to me on account of what perhaps is almost a fad of mine, that is, my positive objection to wire cable suspension bridges under any and all circumstances from what I consider the practical impossibility of so protecting the interior structure of those cables from deterioration due to the percolation of water over such an enormous exposed surface of the cable in all sorts and conditions of extreme variations of temperature, frost, etc. Almost no kind of covering in the shape of paint can be absolutely relied upon, while it is of course impossible to inspect the interior wires of the cable after it has once been erected, and the consequent popular feeling of insecurity after the bridge has been standing for some years seems to me to be

based upon very sound practical reasons which outweigh the theoretical perfection of any design for a suspension bridge with wire cable. However, with reference now to reinforced concrete, I do not wish particularly to enter into a very deep technical discussion or to attack any particular system of that comparatively new form of construction. I merely wish to give what I consider an instructive experience from my own actual practice, which has lately occurred here, as a caution to others, since this incident may have some bearing on the general question of the probable life of any structure wherein the tested strength of reinforced concrete, new laid, is assumed to represent more or less its permanent value in comparison with "straight concrete" or ordinary masonry.

I am aware of course that the most careful comparative tests of strength have been made. I also fully appreciate the relative cheapness of reinforced concrete for withstanding stresses that ordinary masonry of the same dimensions could not begin to stand, and that an engineer should always be careful in his judgment as to the effect of the particular climatic conditions on the materials which he uses, but I notice in the failure of the Charleston Bridge the important statement that under the coping of the anchorages the effect of frequent wettings and of frost, etc., was bad, while the condition of the cables imbedded in the stone work would seem to have been still worse and impossible of inspection even after the wires had begun to snap one by one in the cable that finally broke. Now, the conditions which I describe below on the little job on this little railway, in a totally different state of climatic conditions, will perhaps show a want of thought on my own part in doing the work, but they have led me to speculate on possible similar action (however much reduced in intensity) in all reinforced concrete, though this case was one of reinforced stone work. The circumstances are as follows:

I had occasion to erect a two-story tower on one of the angles of our main station building in Cartagena, which would rest on four arches forming part of the station platform, which runs the whole length of the building in the form of an arcade, built about 10 years ago, very solid and in perfect condition. I do not send you sketches as the point I wish to emphasize would not be illustrated any better thereby. The foundation for the whole building is in very soft ground and had to be piled with very deep piling; I therefore made the additional weight on the top of the corner of the building as small as possible with light walls, but having necessity for a good vault for valuables, I decided to fill in the four arches between the pillars in the arcade at the base (which are 2½ ft. square). The chamber so formed, with its panels of 2½ ft. walls filling the arches, I figured would give additional strength to the base in case of any possible settlement in any of the arches by distributing the weight better, and I decided further to build into the panels lengths of old rails for the double reason of making the room a strong room in the sense of being burglar proof as well as reinforced for structural reasons. This I did with quite a number of rail lengths pretty close together standing vertically in the body of the wall filling the arches. Now, as to the general conditions, the mortar used was ordinary rich lime and sea sand, which gives the most excellent results here, as may be seen in the magnificent specimens of old mason work in the walls throughout Cartagena. (The fortifications themselves are well worth the study of engineers of the present day; they were, I believe, considered quite wonderful for the period at which they were built, over 300 years ago.) The water used for mixing the mortar was mostly hard and even brackish well water, and the stone not too hard limestone and coral rock. The arches were semicircular, only 10 ft. span, and, to make a long story short, within six months after I had completed my "handsome strong room," I observed the most horrible cracks in every direction from the arches, which began to bulge out three of the corners of the tower more than a couple of inches out of line, and the whole of the heavy walling damaged and disintegrated, due to the chemical action of the mortar on the steel rails, which had swelled with rust to such an extent that my only remedy to prevent disaster was to dig out the whole of those panels and remove the rails, putting iron bands around the outside of the walls and replacing the stone work absolutely without any metal in it whatever. I found the flanges, webs and heads of the rails at least ¼ of an inch thicker than when they were put in, from spongy scale of iron rust. Now, of course, there is very little comparison between good Portland cement mixed with careful precautions with fresh water and clean sand; and rich lime mortar mixed with salt sand and brackish water; nevertheless, I simply ask the question, Has enough thought been given in reinforced concrete to the question of slow chemical action on the embedded metal? and have we had sufficient length of experience of that kind of construction to make it prudent to use it under hard conditions and with such economical dimensions as to give a very low factor of safety as compared with straight stone work, for instance, in arches, water towers and dams, etc.? Although the strength of such works may have been calculated from the most careful experiments as to the stresses that new reinforced concrete will undoubtedly stand, that same concrete in the course of a comparatively few years (however slow the chemical action may be in comparison with this exaggerated example of mine) may possibly have so deteriorated from internal rust and swelling as to ruin the whole structure.

I do not write this long letter necessarily for publication, you may not think the incident worth publishing, but I would nevertheless thank you for a reply if you can give me any data of tests as to the condition of any piece of reinforced concrete that has stood, say, for ten years; personally, I would never use reinforced concrete in any large arch or retaining wall until I had such data, and am still old fashioned enough to prefer solid masonry or concrete even with excessive bulk in such positions where the stability is intended to depend on mass rather than upon resistance to crushing, shearing or tensile strains in a composite steel frame embedded in a casing of concrete probably only more or less impervious to the action of the atmosphere on the metal, and consequently even more dangerous from a variety of other causes due to the chemical constituents of the cement and the steel, which cannot be always uniform, and certainly in practical conditions is more or less disregarded by an isolated engineer in South America, who has not at his hand a perfectly equipped chemical laboratory for testing all the materials he uses, and has to accept from his purchasing agent in the States, in the course of his ordinary work, and who yet may be misled by the wonderful results stated in so many professional papers obtained from the use of reinforced concrete. I for one am at least thankful that I have not used it on any larger scale in my arching of bridges and culverts in replacing construction trestles on this road, but I have had considerable experience otherwise in the use of straight cement concrete, and got excellent results with salt sand and even sea water where the efflorescence of the salt in white patches on the surface was no serious objection.

Yours very truly,

J. T. Ford, M. Inst., C. E.,
V. P. and Gen. Mgr., Cartagena-Magdalena Railway Co.
Cartagena, Colombia, Jan. 17, 1905.

Notes and Queries.

In a recent issue mention was made of a recently installed banana elevator. Our attention is called to the fact that a banana conveyor, 800 ft. long, was installed eight years ago by C. W. Hunt Company for the Boston Fruit Co., at Jamaica, West Indies.

PROPOSED HIGH-PRESSURE FIRE SYSTEM FOR THE BOROUGH OF MANHATTAN, NEW YORK.*

An exceedingly interesting and important report was made Mar. 9 to Mr. John T. Oakley, Commissioner of Water Supply, Gas and Electricity, by the acting chief engineer of the department, Mr. I. M. de Varona. It is proposed to provide a high-pressure fire system to protect an area that has been called the Dry-Goods District of New York, bounded by the hatched lines shown in Fig. 1, with 25th St. as the north boundary and Park Row as the south boundary. In the report that follows provision is made for extending this area northward to 59th St., eastward to East River, and southward to the Battery.

The system resembles, in a general way, that now in operation at Philadelphia. Electric motors are used instead of gas engines, however, to drive the high-pressure pumps. It is also practically the same as that now under construction for the Borough of Brooklyn, but it is planned on broader lines than either. While the system is designed primarily to pump fresh water from the city mains, provision is made for pumping salt water from the rivers in case of emergency. Moreover, the system can be used for flushing the pavements with salt water, if such practice should appear desirable. In round numbers the estimated cost of this high pressure system for the Dry-Goods District is $4,000,000. The money has been appropriated. Bids have already been received for hydrants, and, it is expected that contracts will soon be let for the mains, motors, pumps, etc., so that construction will be under way this summer.

Without further preface, an abstract of the report of Mr. de Varona, will be given.

WATER REQUIRED.—The popular impression that an enormous quantity of water is used for fire purposes is entirely erroneous. The amount of water used for fire purposes in the Boroughs of Manhattan and the Bronx during 1903 was 38,093,000 gallons, and this is practically the average for several years. Comparing this amount with the average daily consumption of about 300,000,000 gallons, it will be seen that the total amount used during the year for fire purposes is about one-eighth of the amount used for all purposes each day, or about 1-25 of 1% of the total consumption. It is thus strikingly shown that the difficulty in supplying water for fire use is not in the total amount required, but in concentrating that amount at the scene of the fire. The amount of water in the distributing reservoirs at all periods is many times in excess of the amount required for fire purposes for an entire year, and the adequacy of the fresh water supply need not, therefore, be questioned. With the motors and pumps now to be installed, the total capacity of the station will largely exceed the total capacity of all the fire engines in the Borough of Manhattan, working under normal conditions, and will be equivalent to approximately two-thirds of the combined capacity of all the fire engines in the Boroughs of Manhattan, the Bronx and Brooklyn, under said normal working conditions. It follows that by the installation of the additional pumps and motors provided for, the combined capacity of the two stations will exceed that of all the fire engines in the Boroughs of Manhattan, the Bronx and Brooklyn. We have so designed the system that salt water can be used either for fire purposes or for street flushing and street sprinkling. The stations have been located near the river front and the mains supplying the engines are so connected and controlled that the simple opening or closing of mechanically driven valves will allow fresh or salt water to be pumped into the system. Under these conditions there could be an entire shut-off of the fresh water supply and still there would be the inexhaustible waters of the East and North rivers to be drawn upon for fire purposes. It is to my mind difficult to conceive of a safer system of supply than the one adopted.

STATIONS.—The plans provide for two stations, Fig. 1, to be built at present, with a possible third station if the operation or extension of the system makes it advisable to increase the available supply. One station is located near the Gansevoort Market on the North River, and the other on the East River at the corner of Oliver and South Sts., near James Slip. These two sites are both outside of the limits of districts in which the fire risk is at all hazardous. A conflagration could not practically affect either station, and certainly could not affect both stations.

The supply of fresh water for the Oliver St. station is shown in Fig. 2. The salt water connection would consist of two 30-in. pipes about 400 ft. in length, taking the water from the end of the pier at the foot of James Slip. With a station using water at the rate of 15,000 gallons per minute, the velocity in the suction mains would be about 4.2 ft. per second.

At the Gansevoort station the water supply is shown in Fig. 3. The velocity, when pumping at the rate of 15,000 gallons per minute, would be the same as for the Oliver St. station.

The location of the stations near the northern and southern limits of the district to be protected at present, is advantageous in providing for a supply for the future extensions to the north and south of the area proposed at present. While I have planned the installation with a view of obtaining the most efficient system, I have also given due regard to the cost and have endeavored to avoid extravagance in the expenditure of the public funds. The stations themselves are to be entirely of fireproof construction, no wood being used in any way. The buildings are of sufficient size to give room for eight pumping units at each station, the present installation to consist of five units. The capacity of each station could therefore be increased from 15,000 gallons per minute to 24,000 gallons per minute without any change in the buildings or mains. Provision will also be made for an independent engine to be used for street flushing and sprinkling, although it is probable that this engine will not be installed until after the high pressure service engines have been erected. At present there are not definite data as to the amount of water or the pressure at the hydrant that the Street Cleaning Department deems necessary for its use, and until this is obtained the size and design of the pump cannot be fixed.

MOTORS AND PUMPS.—The motors are 3-phase 25-cycle electric motors, to be driven by a current at a pressure of 6,000 volts and at a speed of about 735 revs. per min. This is the simplest form of motor at present in use and has been extensively employed both to drive pumps and other types of machinery.

The pumps are to be of the centrifugal type, multi-stage pumps. These pumps are unquestionably the simplest type of machine on the market to use for pumping water either against a low or high head. Each stage of the pump can increase the pressure about 50 lbs. and we would therefore have a 6-stage pump for 300 lbs. pressure. The pump would be directly connected to the motor and the simple operation of a switch would throw the machine into service and give the full pressure in about a minute's time. While a relief valve would be provided for additional precaution, the pumps nevertheless would practically take care of themselves, as they churn water when the pressure rises to the maximum pressure for which they are designed, and no damage would result from carelessness on the part of an employee in not properly setting the relief valve. This type of pump was adopted on account of its extreme simplicity and the small amount of space occupied by the pump and motor. We

*See also "Report on Proposed High Pressure Fire Service for Borough of Manhattan, New York City," by Nicholas Hill, Ch. Engr., Engineering News, March 24, 1904, p. 287.

have just started a 2-stage centrifugal pump, driven by a steam turbine, at the Mt. Prospect Pumping Station, which has shown a capacity of 6,600,000 gallons in 24 hours against a pressure of 72 lbs. The contract capacity for this pump was 6,000,000 gallons per day.

In the Schenectady water-works two centrifugal 2-stage pumps are installed working against a pressure of 110 lbs. and with a capacity of 12,000,000 gallons in 24 hours. They are directly connected to 800 HP. 3-phase 40-cycle induction motors. The pumps have been in use for 1½ years, and, I am informed, have been approved by the Board of Underwriters.

The Buffalo Water-Works are about to install 2-stage centrifugal pumps of 25,000,000 gallons capacity, operating against 70 lbs. pressure, directly connected to 1,250-HP. 3-phase, 25-cycle motors.

The Youngstown Fire Department operates a centrifugal pump of 500 gallons per minute capacity against a head of 175 ft., driven by a 40-HP. 400-volt, 2-phase induction motor, with a speed of 840 revolutions per minute.

At the World's Fair in St. Louis there were three centrifugal pumps single stage with a capacity of 35,000 gallons per minute working against a head of 150 ft., directly connected to 2,000-HP. Westinghouse motors.

The manufacturers who build these pumps include the following well-known firms, i. e., Allis-Chalmers Co., Henry R. Worthington, I. P. Morris Co., Lawrence Machine Co., D'Olier Engineering Co., Power Specialty Co., and Stillwell-Pearce-Smith-Vale Co., and these manufacturers have gone over our specifications and are willing to bid under them and guarantee, under ample bonds, that the pumps they furnish can and will do all the work required.

I cannot see, therefore, how there can be any criticism as to the practicability of the type of motor and pump proposed, and with the ten units that we will have at the two stations it is well nigh impossible that any serious interruption to the supply could be apprehended.

The electric current necessary to run the stations would be furnished by the New York Edison Company, at a pressure of 6,000 volts. This company has six steam generating and distributing stations. These stations are also partially equipped with rotary converters and storage batteries, so that in case of a breakdown of the machines, the storage batteries and converters can be put into use. The total engine horse-power of the stations at present installed, and of those being built, is 297,550 HP.

In addition to this power the company has feeders connecting with the Brooklyn Edison Company, so that they can be called upon for additional current, if required.

There are 15 substations supplied by current transmitted from Waterside stations.

All of these substations are, with the exception of the Bowling Green plant, property of the New York Edison Co., and each is equipped with rotary converters and storage batteries and is fully equipped as a permanent center of supply. The storage battery system, at present in the substations and generating stations, aggregates 30 batteries of 4,000 amperes each per hour at 135 volts, thus giving a reserve capacity, if all generating ceased, of over 120,000 ampere hours at 135 volts. As the total amount of current that can be used by both stations, when working under full capacity, would not exceed 6,500 KW., it will be seen that there is an enormous reserve in the Edison system.

Fig. 1 shows the Edison system with the connecting feeders, and also location of our proposed high pressure fire service stations, and the feeders connecting the Edison system with the pumping station. Each station will have two 250,000 C. M. 3-phase cables laid in ducts, each feeder being entirely independent. In addition to these feeders, there will be a tying-in feeder between each pumping station and a substation of the Edison Electric Company. Under these conditions it would certainly seem almost a physical impossibility that any interruption of the power supply need be apprehended.

MAINS.—The general scheme is to have two 24-in. discharge mains leading from each station. These mains bound almost the entire area to be protected and run from one station to the other. Sixteen-inch and 12-in. mains are to run in streets paralleling and intersecting these mains and they are cross-connected at frequent intervals by 20-in. mains. The 12-in. mains are only used for lateral branches and are not dependent upon as arteries for carrying the supply. These mains, together with the 16-in. mains, are connected at short intervals with 20-in. mains, so that the water only has to travel a short distance through a main smaller than 20-ins. before it reaches the hydrant from which it is to be drawn. All mains are cross-connected at the points of intersection so as to obtain the most perfect circulation possible. With this cross-connection, and with gates located at the end of every block—except for the very large mains, where the gates are spaced about two blocks apart—it is possible to repair a break in any single block without affecting any hydrants except those located on the block in question. This system makes it practically impossible for any break in a main to appreciably affect the supply or pressure.

Careful computation of the frictional losses in the mains shows that the full capacity of both stations can be delivered in any section within the area at present proposed with a pressure at the base of the hydrant of about 250 lbs. per sq. in. These computations were based on the pipe formulas for friction in cast iron pipes of Flamant, and checked by Darcy's formula, both of which are considered reliable by hydraulic engineers.

Under the proposed plan, the hydrants are always within 400 ft. of any building in the district and there are sufficient hydrants so that, if any block were on fire, 60 streams of 500 gallons per minute, or the full capacity of both stations, could be concentrated on a block with a length of hose not exceeding from 400 to 500 ft., assuming the use of 3-in. hose and 1½-in. nozzle. This affords adequate provision.

In case of an extension of the system to the Battery, and with the James Slip station out of service, the full

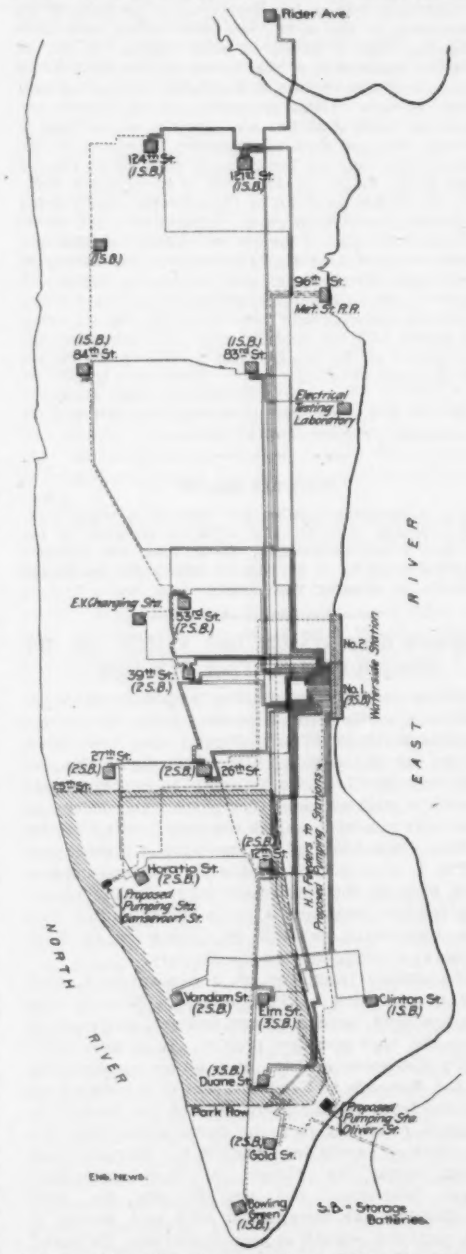


Fig. 1. Map Showing Location of Electric Power Stations and Pumping Stations for Manhattan High Pressure Fire Service.

capacity of the Gansevoort station could be concentrated at the Battery with a pressure at the base of the hydrant of not less than 255 lbs. It will thus be seen that either station can break down without crippling the system, although, of course, the capacity would be reduced by one half. It has, however, been previously shown that with the stations located as they are, and the pumping plant divided into so many units, it would be almost a practical impossibility for any station to completely break down. The lay out of the mains at the station, both for suction and delivery, would be on the loop system, i. e., the supply could be taken from either one of two mains and discharged through one of two mains or through both. Gates, of course, would be placed so as to control the discharge from each unit and from each main. With such a system, even the breakdown of one of the discharge mains at the station would only slightly reduce the pressure at the fire and would not affect the capacity of the station, as the pumps would be capable of forcing their full capacity through the short length of [illegible] 24-in. main that would be necessary under condition[illegible]ated by such an accident.

The mains are to be of cast iron and of the [illegible]sing thickness:

Size of pipe, inch.	Thickness, inch.	Unit tensile strain with 300 lbs. pressure.
24	1⅜	1920.
20	1⅛	2000.
16	1¼	1920.
12	1	1800.
8*	⅞	1371.

*Only used for hydrant branches.

The special castings for the large 3-way and [illegible]way branches, where they are weakened by the area [illegible]out for the branches, are to be made of steel and a ve[illegible]rge factor of safety provided. The other specials are [illegible] of cast iron and are also designed with a very large [illegible]tor of safety. The joints shown in Fig. 5 are of a [illegible]cial form, designed to meet the requirements of th[illegible]igh pressure. There are deep double lead grooves in b[illegible] the spigot end and hub end of the pipes. Tests made with the ordinary 12-in. lead joint showed that it held [illegible] to 750 lbs. per sq. in., which was the highest test pressure we could obtain, and with the grooved joint it would not seem possible that any difficulty can be experienced. The contract provides a maximum leakage allowable for each lineal foot of joint under a test pressure of 450 lbs. per sq. in., this leakage being measured by pumping through a meter for a period of 10 mins. The pipe and steel castings are to be tested to a pressure of 650 and 700 lbs. per sq. in. respectively, at the foundry. This, together with the test in the field, should, as near as possible, absolutely guarantee that the mains and appurtenances will be capable of safely withstanding the working pressure, which is about one-half of the foundry test pressure and about 70% of the field test pressure.

As under normal conditions there will be little or no flow in the main, they are to be laid so that the outside top will be at least 5 ft. below the surface of the street, or about 1½ ft. below frost line. Where it is necessary to bring the main closer to the surface, special arrangement will be made to prevent freezing, and during the winter months water will be slowly pumped at frequent intervals from one station to the other so as to change the water in the mains.

GATES.—The gates or stop-cocks are to be of cast iron, and no larger gate than 20-in. to be used in the system. All gates 12-ins. and larger are fitted with by-passes so as to relieve the pressure on the disk, and for the 24-in. mains 20 × 24-in. reducers are to be used with the 20-in. gates. The stems for the gates are to be of nickel steel, in order to combine extreme strength with freedom from corrosion, and all other working and bearing parts are to be of bronze composition. The gates are to have flanged ends with a short bell or spigot piece bolted to the gate, so that in case of a break in the gate it can very quickly be removed and a new gate placed in position. As previously stated, these gates are placed approximately every block, except on the very large mains, thus avoiding the cutting out of more than one block in case of any break in the main.

HYDRANTS.—The bids have already been received for the hydrants for the entire installation, and under the specifications the bidder is to submit a sample hydrant which is to be thoroughly tested before the award is made for the hydrant. The more important requirements for the hydrants are that the main valve will be so designed that the pressure of water will tend to close it; that bronze be used for all metal parts of the valves and valve seats; that no movable iron part shall come in contact with cast iron; that there shall be four nozzles, one 4½-in. and three 2½-in. standard outlets; that all outlets shall be controlled by independent valves of composition having rolled Tobin bronze stems; that the clear waterway through the main valve shall be not less than 28 sq. ins. and the internal diameter of the standpipe not less than 9 ins.; that the inlet at the base of the hydrant shall be 8 ins. internal diameter and flanged; that the hydrant shall be so designed that all valves, seats, spindles, etc., can be removed without disconnecting the hydrant; that the main valve and drip valve cannot be opened together; that the main valve can be opened and closed by one man, using a 15-in. wrench, when the hydrant is under the maximum working pressure of 300 lbs. per sq. in.; that the fireboat connection hydrants shall have two 3½-in. fire department standard female connections to fit with the fireboat connections; that each hydrant shall be tested under 300 lbs. and 600 lbs. pressure, both with the main valve closed, and with the main valve open and independent valve closed; that the hydrant shall be perfectly tight under 300 lbs. pressure and not show a greater leakage than ½ ounce per minute under the 600-lb. pressure. To make certain that the hydrants submitted comply with the requirements, a thorough test of the sample hydrant submitted is to be made before the award of the contract is made. These tests will be as follows:

1. Under a static pressure of 300 and 600 lbs., respectively.

2. When pumping through a hydrant with one of the fireboats, at a pressure as near 300 lbs. as it may be

safe to use the fireboat. While this pumping is going on the hydrant will be opened and closed to observe the facility of operation, freedom of water hammer, etc.

3. All valves, valve seats, spindles, etc., will be removed from the hydrant and the same reassembled, and then subjected to a final test under a static pressure of 300 and 600 lbs.

The hydrant is called for under the specifications is an improvement over that adopted by the United States Government at Washington, and also that adopted by the City of Philadelphia, this being due mainly to the experience obtained by these cities from tests of the hydrants that the supply of water will be cut off therefrom when the pressure in the main rises above any prescribed limit, say 70 lbs. This provision is necessary to prevent injury to the men in the street cleaning gangs when at work sprinkling or flushing, if, while doing this work, the pressure is suddenly raised without warning. The street sprinkling and flushing hydrants will be of an entirely different appearance from that of the hydrants in use, as well as from those to be installed for the high pressure fire system, and will be plainly marked so as to offer no doubt as to the purpose for which they are intended. The high pressure fire service hydrants are to

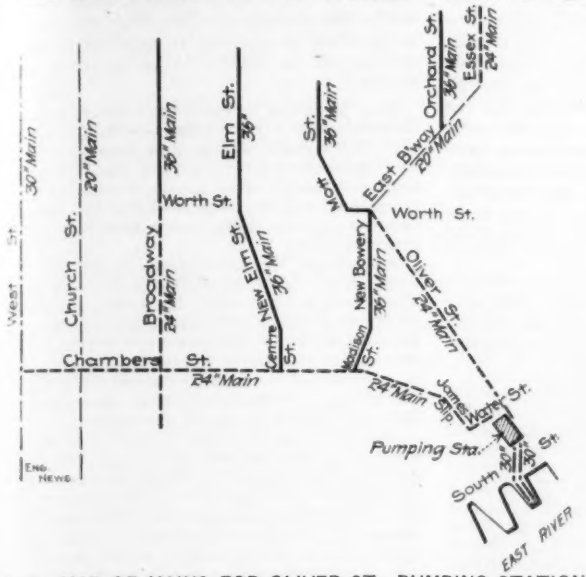


FIG. 2. MAP OF MAINS FOR OLIVER ST. PUMPING STATION.

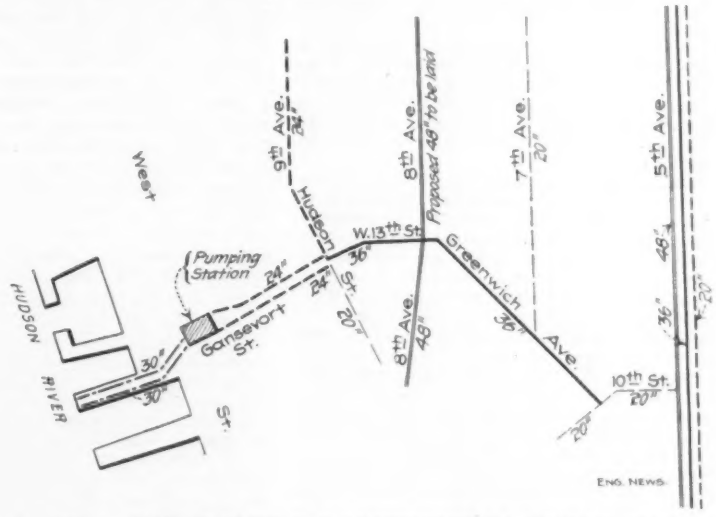


FIG. 3. MAP OF MAINS FOR GANSEVOORT ST. PUMPING STATION.

submitted to them, and the above statement is not intended as any criticism on their hydrant or specifications for the same.

To drain the hydrant, a 1-in. lead lined drip pipe is connected directly from the hydrant to the sewer, thus insuring a perfect draining of any water which may be in the hydrant after a fire, or which may leak through the valve. As the depth of the inlet to the hydrant is at least 6 ft. below the surface of the ground, no fear should be entertained of the freezing of the hydrant, unless it is defective.

FIREBOAT CONNECTIONS.—We originally intended to locate the hydrants at the bulkhead line of piers on the river front, where no difficulty from freezing might be anticipated, but Mr. Croker (Chief of the Fire Department) claims that the fireboat connections should in every case be carried out to the end of the piers, because in the winter it would be difficult, if not impossible, to reach the bulkhead line on account of the ice in the slips, and also because the slips are blocked at night by vessels of various descriptions. Recognizing the validity of the criticism made by Mr. Croker, the hydrants will

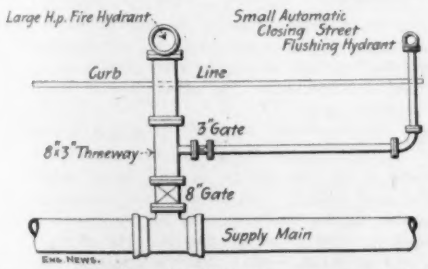


Fig. 4. Connections for High Pressure Fire Hydrant and Street Flushing Hydrant.

be located at the end of the piers, unless in special cases a different course is deemed advisable. Automatic appliances will be provided for emptying the main during the winter time to prevent freezing and the hydrants will be carefully covered and protected to guard as much as possible against danger from freezing resulting from their necessarily exposed position.

STREET SPRINKLING AND FLUSHING.—This bureau has neither recommended nor opposed the use of the high pressure fire system for street sprinkling and flushing. In accordance with directions received, however, the system has been so designed that it can be used for street cleaning purposes, but special care has been exercised to avoid any reduction in the efficiency of the system from a fire standpoint by the street cleaning appliances. On each hydrant branch a 3-way branch has been set between the cap and the hydrant and to this will be connected a small cast iron gate with a flanged pipe leading to the street cleaning hydrant. Fig. 4 illustrates the proposed arrangement. The hydrant will be so designed to be operated exclusively by the employees of the fire department.

To provide the requisite water for street sprinkling and flushing, independent pumps will be ultimately installed at the stations, as the high pressure pumps are unsuited for this service, but as at present there are no definite data as to the amount of water required and pressure needed for street sprinkling and flushing, the installation of these special pumps will be delayed until these points are definitely settled. In the meantime the high pressure fire service pumps will be temporarily used. We are at present in consultation with Commissioner Woodbury of the Street Cleaning Department to ascertain his wishes in regard to the location, type and number of the hydrants to be installed for street sprinkling and flushing, and specifications of the hydrants could be readily completed and included in the contract of laying and furnishing mains in the Borough of Manhattan.

TELEPHONE BOXES.—The system of telephone boxes proposed is similar to that in use by the Police Department, the boxes being located so that a fire in any part of the district can be watched from at least one of these telephone boxes and orders readily transmitted to the engineer of the pumping station in regard to the requisite pressure and amount of water needed, as well as to the use of fresh or salt water, thus saving invaluable time. These telephone boxes have been successfully installed and operated in the Philadelphia system. I had thought that the Fire Department might possibly be able to do this work more economically, as they have a fire-alarm system, but as the result of recent communications on the subject with the Commissioner of the Fire Department, and under his decision, the installation of the boxes will be made by this department.

ENGINEERS.—Were it not for the great interest and energy displayed by each one and all the assistant engineers and others who have taken part in this work, it would not have been practicable to produce the results accomplished during these five weeks in as many months. The assistant engineers employed in the work on the Brooklyn system, and in a considerable portion of the work on the Manhattan system in order to expedite the completion of the latter, have been Principal Assistant Engineer Robert Van Buren and Assistant Engineers W. W. Brush, Charles D. Ward, B. M. Wagner and Joseph Goodman, and the assistant engineers on the Manhattan work have been Messrs. Daniel A. Curtin, Geo. A. Taber and Thomas J. Gannon.

PHILADELPHIA FIRE SYSTEM.—The largest system of independent mains under high pressure installed in any American city for fire protection is located in Philadelphia, and has been examined and personally inspected by almost all the engineers desirous of thoroughly studying this plan. The system was recently installed, having been in service about eighteen months, and was operated by fireboats before the completion of the central pumping station; since then the use of fireboats has been discontinued. Among the criticisms made by Mr. Croker, as published in the daily press and echoed in some of the articles which have recently appeared, is the statement that the Philadelphia fire system has proved a failure. Such is far from being the case, as shown by a letter of Mr. F. L. Hand, Chief of Bureau of Water, and a letter of Mr. David J. Smyth, Director of the Department of Public Safety of Philadelphia, both letters having been written in answer to communications addressed by me requesting a full statement of the facts of the case. In addition to the conclusive testimony afforded by these letters, it is important to add that the representatives of the insurance companies in Philadelphia, who had entered into an agreement to make a reduction of 25 cts. per $100 on the completion of the high pressure fire system for that city to their satisfaction, carefully inspected all the details of that system both while under construction and after its completion and supplemented this inspection by a thorough supervision, if not direction, of the final tests made to determine the efficiency of the system when it had been totally completed.

With these precedents before us, we have at hand the most valuable data to pass upon the efficiency of the plans now proposed for the Borough of Manhattan, so that a brief comparison of the main features of our plan with that adopted for Philadelphia will be of interest. As a preface to this comparison, it may be well to state that a reduction similar to that made in Philadelphia on insurance rates would, in the Borough of Manhattan, represent an extremely large annual saving, of which I regret not to give now the exact amount owing to my inability as yet to obtain the insurable values in the protected district. In Brooklyn, where the values are much less than in Manhattan, such a reduction, however, would amount to a saving of about $550,000 a year, which represents about 7.7 times the total estimated cost of maintenance

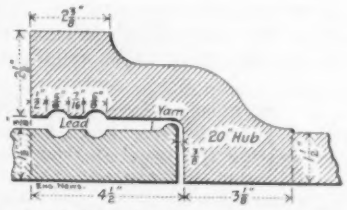


Fig. 5. Lead Joint for High Pressure Fire Mains.

and operation, plus interest and sinking fund charges, for the high pressure fire system in Brooklyn.

COMPARISON OF PHILADELPHIA AND MANHATTAN SYSTEMS.

AREA PROTECTED.—The mains of the Philadelphia system extend over an area about 2,500 ft. wide by about 6,500 ft. long. The corresponding area in Manhattan will be about 11,200 ft. long by about 5,200 ft. in width, or covering a total area about three and one-half times the Philadelphia area.

WATER SUPPLY.—The supply for the Philadelphia station is taken from the Delaware River through a single suction main. No provision is made for a supply from fresh water mains, while in the Manhattan system both the fresh water supply and the river supply are available. There are also double supply mains from both sources of supply, instead of one, as in the Philadelphia system.

STATIONS, MOTORS AND PUMPS.—The Philadelphia system has only one station, the combined capacity of the seven units being about 10,400 gallons per minute. The pumps are triplex, double-acting, geared plunger pumps, driven by gas engines. In the Manhattan system there are two entirely independent stations, each of a capacity

about one-half greater than the capacity of the Philadelphia station, and the pumps are centrifugal pumps, driven by electric motors. The electric motors and centrifugal pumps are a simpler type of machine than the Philadelphia machine, although either one should give uniformly efficient service, the main advantage of the Manhattan system being its duplication and greater capacity.

MAINS, GATES AND HYDRANTS.—The Philadelphia system is dependent upon one 20-in. discharge main, which branches out a short distance from the station into 16-in. mains. Any break in this main would cause a complete stoppage of the station. There are three 12-in. mains and one 16-in. main leading from the river front towards the City Hall, and these mains are cross-connected by 8-in. mains at intervals of about every three blocks, or about 1,500 ft.

In the Manhattan system there are two 24-in. mains from each station and these are supplemented by 20-in., 16-in. and 12-in. mains. The smaller mains are generally laid on east and west lines and on every block and are supplied by the trunk mains laid on streets running north and south and at intervals of about 1,000 ft., or about every four short blocks.

The system of spacing the hydrants and gates is very similar to that adopted for Philadelphia. The mains in both cases are of cast iron, but in the Philadelphia system flanged pipe was used and after its completion lead expansion joints were inserted to overcome the difficulty experienced with the temperature stresses in the flanged pipe. As has already been stated, the joints for the Manhattan system are to be of lead, except at the gates.

The hydrants installed at Philadelphia are of the gate type—the pressure tending to force the valve off its seat. The Manhattan hydrants will be of a compression type and the tendency of the water will be to close the valve. The Manhattan hydrants, as already stated, will have one 4½-in. and three 2½-in. outlets instead of two 4-in. outlets, as provided in the Philadelphia hydrants.

TELEPHONE BOXES.—The telephone boxes would be designed after the Philadelphia system and would not differ materially from that in use there.

In making the above comparisons between the system we propose with that in use at Philadelphia, I desire to state emphatically that it is far from my purpose to criticise the installation at Philadelphia, which, on the contrary, deserves high praise as the pioneer large system in the country, while its successful operation bears the most eloquent testimony to the intelligence and skill shown both in its design and execution. It is mainly from the experience gained in this installation and freely and most kindly communicated to us by Mr. F. L. Hand, Chief of the Bureau of Water, and his assistants, that we have been able to design in Manhattan and Brooklyn systems with the improvements which have been enumerated above.

The underlying principles followed in designing the high pressure fire system for Manhattan, its main and even secondary features, our purpose to lay it out on broad but not extravagant lines, and its adaptability to such extensions hereafter as may be warranted by the results obtained after it has been in operation, may be all readily investigated and determined by all parties interested by reference to the comparatively full statement herein given and which I shall now bring to a close.

REPORT ON METHODS OF INCREASING THE CAPACITY AND DEADENING THE NOISE OF THE LOOP TERMINAL OF THE CHICAGO ELEVATED RAILWAYS.

The congestion of traffic and the noise due to operation of the Chicago elevated loop (Union Elevated Ry.) have been the cause of numerous complaints, and the city council's Committee on Local Transportation appointed Mr. Bion J. Arnold to investigate these matters. His report has recently been issued, and from it we have compiled the present article. The matter of reducing the noise was discussed in our issues of Nov. 17 and Dec. 15, 1904.

INCREASING THE CAPACITY.

The Union Elevated Ry. loop is a double track line two miles long, serving as the terminals for four railways (one of which has four branches), and these enter the loop at three of its corners. The traffic is about 1,600 trains per day, each train having from 2 to 5 cars. The bulk of the traffic is handled during 90 minutes in the morning and 90 minutes in the evening, while the maximum congestion lasts for about 30 minutes during each of these periods. At these time the average headway is 19.8 seconds on the outer track and 19.5 seconds on the inner track. The ultimate capacity of the loop is fixed by the number of trains that can be passed through the three junctions, but under existing conditions the capacity is limited by the station platforms. At each station the front half of the platform is used for trains of one road and the rear half for those of another. There are 11 stations, with an average distance of 955 ft. between them, and very frequently the trains have to slow down or stop to allow the train ahead to move out of the way. The remedy for this is to lengthen the platforms, so that two trains of each line could use a station simultaneously; this the company has commenced, but its work has been stopped, pending litigation by property owners.

Under present arrangements, each train entering the loop passes entirely around and leaves again at the same point. Mr. Arnold proposes a through routing of certain trains; that is, a train from the South Side line might pass around two sides of the loop and then run out on the Northwestern line, but this plan is hampered by the fact that the several lines are owned by independent companies. Should consolidation take place, the matter would be very much simplified. The most comprehensive scheme submitted includes elevating certain parts of the tracks so as to avoid the present grade crossings at junctions. The maximum grades would be 1½%, and 0.5% near stations. Three of the elevated railways have head-house or dead-end terminals just outside the loop, but only one of these is used to any extent, and a greater development of the facilities offered by these terminals is suggested.

The perfection during the past few years of power mechanism for operating switches and signals at junction points has been such as to warrant its adoption on the loop, and if used the capacity of the junctions could be somewhat increased owing to the quicker action of the mechanism. When the advantages of this improvement and of the use of "the multiple unit system" on the cars are utilized, I know of no way that the capacity of the loop, as now built, can be increased under the present method of individual ownership operation except by extending the platforms. When this is done, relief to the present loop district must come from the development and operation of stub-end or other terminals for each road, unless unification or some method of joint operation can be effected whereby through routing can be adopted.

The recommendations made may be summarized as follows:

1. Provide for through routing of trains. Reconstruct the junctions, elevate portions of the tracks, install new interlocking power mechanism, and extend the platforms; $500,000 (including alterations to stations and structure and the installation of escalators).

2. Provide for through routing of trains, reconstruct the junctions, install new interlocking power mechanism and extend the platform; $80,000 or $97,000, according to different plans submitted.

3. Leave the loop as it is now, install power mechanism for the interlocking plants, and extend the platforms.

Each of these proposals comprises the development of dead end or auxiliary terminals.

REDUCING NOISE ON THE ELEVATED LOOP.

Between 1871 and 1878 the Manhattan Elevated Ry, of New York made a number of experiments, in which the rails were laid upon and surrounded by sand, asphalt and felt, lead, etc., but the deadening effect was not sufficient to warrant carrying any of these plans into execution. When the New York Central Ry. completed its steel viaduct from the Harlem River to 110th St., New York city, in 1897, the rails were bolted directly to the floor, which was composed of rectangular transverse troughs. The noise was so great that damage suits were commenced, and the company's engineers experimented with different materials for filling the troughs (including sawdust mixed with asphalt). This plan did not prove satisfactory, and the plan adopted was to fill the troughs with broken stone, and embed ordinary sawed ties in this, carrying the rails clear of the floor. This was so far effective that the damage suits were withdrawn. On the Liverpool elevated railway, the floor is composed of transverse steel troughs, inverted, with a filling of asphalt and ballast, while the rails are laid upon longitudinal timbers resting directly upon the steel floor. On the Berlin electric elevated railway (Eng. News, May 15, 1902) the structure in the western or residential part of the city has a floor of steel buckle plates (concave from above) resting on the tops of transverse I-beams, and carrying a bed of gravel ballast in which the ties (30 ins. c. to c.) are embedded. In the eastern part of the city the floor has steel buckle plates (convex from above) resting on the lower flanges of the I-beams which are 5 ft. apart. On the top of each I-beam is laid a wooden tie.

The Chicago elevated loop has steel bents 12 ft. apart, c. to c., each bent having a pair of columns 25 ft. 2½ ins. c. to c., with a transverse plate girder between them. Between these girders are four lines of lattice deck trusses. The rails are spiked to ties resting directly upon the trusses. While this construction is not questioned from an engineering standpoint, it presents difficulties in attempting to modify it so as to deaden the sound.

Were the present structure not in place, I am firmly of the opinion that a concrete structure could be designed and built which would prevent to a large degree the noise now emanating from the present steel structure, for a cost which would not be greatly in excess of the cost of the present structure; but to change the present structure into one resembling such a form is a difficult and expensive task.

In analyzing the relative merits of different classes of construction, the fact should not be lost sight of that the noise comes primarily from the trains, and a large part of this noise cannot be eliminated entirely, no matter how good the design of the structure. The best, therefore, that can be expected is to minimize the noise caused by the operation of the trains to the greatest possible extent, and prevent it being intensified by the supplemental action of a vibrating or ringing instrument.

The ure of concrete would eliminate almost all of the difficulty encountered with the present structure due to vibration, and if, in addition, the structure were carried up solid on each side of each track to a point slightly above the bottoms of the cars, the noises produced by the wheels upon the joints and by other working parts of the train would be largely confined to the space underneath the train, and would to a certain extent dissipate themselves and be prevented from being immediately transmitted in a horizontal plane to the sides of the tall buildings on each side of the structure, thence upward to the annoyance of the occupants of the upper stories as at present. This class of construction would be objected to by the operators of the road, owing to the fact that it would introduce difficulties in removing ties; but in answer to this it may be said that the underground railroad of New York (the latest to be constructed), as well as the Berlin elevated road and others, have at the present time this objection in a greater or less degree, so that it should not be considered prohibitive if, by its adoption, other advantages could be gained. Furthermore, the ties on an elevated structure should last many years and the use of concrete-steel ties, similar to those now beginning to be used in steam railway service, would almost entirely eliminate this objection, as they would seldom, if ever, have to be renewed.

Since it would be manifestly unjust to ask that the present loop structure be removed, and thus permit the erection of a design of this character, the problem is then how best to modify the present design so as to reduce the noise to the greatest possible extent without making the cost prohibitive.

There are four primary causes of noise from the loop: 1, Imperfect track construction; 2, Imperfect rolling stock; 3, Imperfect roadbed; 4, Defects in structure (A, elasticity of the steel; B, lack of rigidity).

1. IMPERFECT TRACK CONSTRUCTION.—Mr. Arnold states that the hammering of the wheels over the joints is the chief source of noise, and that it is of importance that the joints and the entire track should be built and maintained in first class condition. He recommends the use of 80-lb. rails; "having the ends mitered or cut at an angle of about 40° and provided with some first-class joint of the bridge type, such as the Continuous, the Weber, or other equally as good." While he recognizes that the miter joint has been abandoned in steam railway practice, he believes it will be a practical advantage in this case. He also speaks favorably of the Haarman-Vietor scarf joint, as used on the Prussian State Railways and the Berlin elevated railway. The special work should be reduced to a minimum and rebuilt with manganese steel parts, while movable point frogs or other forms giving a nearly continuous rail should be used. The rails should rest on large and heavy tie plates, and be secured to the ties by screw spikes or otherwise so as to prevent rattling, and should be maintained in this condition.

2. IMPERFECT ROLLING STOCK.—The rolling stock consists mainly of rather light cars, and much of the noise proceeds from the running gear,

brake beams, defective gears, loose bolts, etc. To deaden this, the suggestion is made that the entire truck should be enclosed with a light casing of sound-deadening non-combustible material. The use of motor cars on two of the roads also causes excessive gear noise in accelerating trains, and this can be eliminated by the introduction of the multiple-unit system. Sound deadening material should also be filled into the hollow places of the floor and sides.

3. IMPERFECT ROADBED.—The report shows a number of designs of ballasted floors, with decking of steel, wood and concrete; all of these provide for 12 ins. of ballast, giving a depth of 6 ins. under the ties and ballast is filled between the ties and against the webs of the rails. In all but one of the designs, the floor is continuous; the exception has transverse troughs of reinforced concrete, 17 ins. wide and 7 ins. apart in the clear, with concrete troughs between them under the rails. The cost per ft. of double track is estimated at $63.30 for a floor of transverse I-beams carrying a steel deck plate, $11 for a deck of transverse timbers laid close together, $8 for a reinforced concrete monolithic floor, and $6.25 for the open floor of reinforced concrete troughs. These figures include ballast, but not track (rails, joints, ties, guard timbers, fastenings, etc.). No definite recommendation is made, but a trial of different methods on experimental sections of line is suggested. Each track would have its own floor system with concrete side or parapet walls extending 3 ft. 2 ins. above the tops of the ties. The space between the tracks would be for cables, etc. At junctions, and crossovers, however, the floor system would extend over the space between the tracks.

4. DEFECTS IN STRUCTURE.—The additional weight due to any of the suggested floor systems increases the stresses in the structure and necessitates its reinforcement. Plans have been prepared for reinforcing by steel and by concrete. The steel reinforcement would be made by adding plates to the top and bottom flanges of the longitudinal and cross girders and to the inner faces of the columns. This would cost from $22 to $33 per ft. of double track, as against $17.30 for concrete steel.

In applying the concrete-steel reinforcement, the stringers, girders and posts would be encased in concrete, in which there would be embedded steel bars wherever necessary to make up the deficiency in section and also to carry the weight of the concrete itself. The adhesion between the concrete and the present steel structure would not be depended upon, but would furnish an additional increment of strength. To still further reduce the noise-producing effect of the steel structure, it would be best to encase the laterals and transverse bracing. The reinforcement should be applied by means of concrete-steel forms, which would remain in place and serve as a facing. After the concrete has set, and when the bond between it and the steel becomes established, it is probable that no force which the structure will bear would separate them. This construction has a precedent in the reinforcement of old girders on the Wabash Ry. There would be no difficulty in providing for expansion; the greater volume presented by the concrete reduces the effect of temperature changes, and also reduces the deflection of the steel girders. Since experiment and experience both demonstrate that concrete follows steel close to its elastic limit, there is no good reason for anticipating serious difficulty from cracking, provided the concrete is allowed to set before live load is applied. Aside from its value as a reinforcement and in eliminating the noise of the steel structure thus encased, the concrete reinforcement would serve as a preservative of the present steel structure.

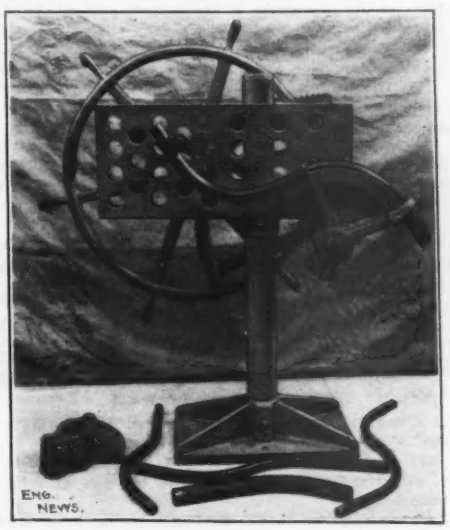
A NEW PIPE BENDING MACHINE.

We illustrate herewith a machine for bending pipes up to 2 ins. diameter. It is operated by one man, and, it is claimed, a piece of 2-in. pipe can be bent into an S in 3 mins.

The machine is operated by a hand-wheel which carries a pinion. The latter, engaging a quadrant gear, operates the bending quadrant. The pipe to be bent is held in position at one end by a U-shaped clip while a pin or roller placed in the platen engages the other end. The placing of the pin or roller in the different holes in the platen governs the curvature obtained.

Contractors having to make gas-pipe hand rails will find this machine a saver of money; and, it is obvious, that pipe shops and machine shops, where much pipe work is done, should be equipped with a machine instead of relying upon the old method of bending a sand filled pipe by hand.

This pipe bender was patented May 17, 1904, and is manufactured by Pedrick & Smith, 222 to 226 E. Girard Ave., Philadelphia, Pa.



A New Pipe-Bending Machine.

COMMITTEE REPORTS OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.

The reports of 13 of the committees have been published in advance of the annual meeting of the association, held in Chicago, March 21, 22 and 23, and in accordance with our usual practice, we present abstracts of several of these.

BALLASTING.

While there is great variation in the qualities of the different natural materials for ballast, the choice of these qualities is not usually left to the engineer, but has been made already by nature, and all that is left to decide is what is most available or most expedient. This each one must decide for himself in the light of his own circumstances. The question of finance may be a ruling consideration or there may be but one thing available. In the case of crushed rock, however, the process of manufacture being under control, it is practicable to make the product conform to specifications. The following were adopted by the convention of 1904. The committee sent out a circular asking for specifications of various roads covering crushed rock, but the replies indicated that very few roads used specifications covering any more points than those given.

STONE BALLAST.—1. Quality: A. Stone shall be durable enough to resist the disintegrating influences of the climate where it is used; B. It shall be hard enough to prevent pulverizing under the treatment to which it is subjected; C. It shall break in angular pieces when crushed.

2. Size: A. The maximum size of ballast shall not exceed pieces which will pass through a screen having 2-in. holes; B. The minimum size shall not pass through a screen having ¾-in. holes.

GRAVEL.—Gravel should be screened or washed where prevention of dust is an object, and it is recommended that this be done where the proportion of sand or clay exceeds 50%. The minimum size should be such as is retained on screens of 12 meshes per inch, in a thorough, careful test.

CINDERS.—The use of cinders as ballast is recommended for the following situations: On branch lines with a light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; in cuts and on fills; as sub-ballast on new work where dumps are settling, and at places where the track heaves from frost. It is recommended that provision be made for wetting down cinders immediately after being drawn.

BURNT CLAY—The material should be black gumbo or other suitable clay free from sand or silt. The suitability of the material should be determined by thorough testing in small test kilns before establishing a ballast kiln. The fuel used must be fresh and clean enough to burn with a clean fire. It is important that a sufficient supply be kept on hand to prevent interruption of the process of burning. Burning should be done under the supervision of an experienced and competent burner. Ballast should be allowed to cool before it is loaded out of the pit. Absorption of water should not exceed 15%.

OYSTER SHELLS.—The following notes are kindly furnished by Mr. F. L. Nicholson, Engineer Maintenance of Way, Norfolk & Southern R. R.

We find that oyster shells are the best for our purpose; they are purchased from oyster packers in this section at prices ranging from 2½ to 3½ cts. per bushel. As we have no special cars for handling ballast, they are loaded into gondolas and by opening the doors partially, they are distributed on the track while the train is in motion. The drainage properties are almost perfect, therefore the life of the tie is extended—how much we are unable to say at this time.

There is an entire absence of dust. They somewhat reduce vegetation but do not entirely prevent it. There is always more or less dirt mixed with the shells, and this with the lime will support the life in certain kinds of weeds, and these have to be pulled out by hand. We now have about 40 miles of track ballasted with oyster shells, and during the time we were ballasting there was on an average one high-speed train per hour on this track. The following is table of particulars:

Bushels per mile	42,266.
Cubic yards per mile	2,113.3
Cost of shells per bushel	$ 0.0274
Cost of shells per cubic yard	0.5480
Cost of labor per cubic yard, shells	0.1744
Cost per cubic yard in track	0.7224
Cost per mile—labor	368.64
Cost per mile—oyster shells	1,158.62
Total cost per mile	$1,527.26

We paid our foremen at the rate of $42 per month and laborers $1 per day for ten hours.

GRANULATED SLAG.—The following notes on granulated slag were prepared by Mr. Samuel Rockwell, Assistant Chief Engineer, Lake Shore & Michigan Southern Railway:

Slag naturally falls under two heads: 1, that which is hard and vitreous and that will not slake, and, 2, that which will slake, the latter being due principally to an excess of calcium and deficiency of magnesium oxides. Vitreous slag broken in sizes similar to broken stone makes fair ballast, but the lime slag is not good, as after slaking it sets into a solid mass almost resembling concrete.

In order to facilitate and cheapen the handling of slag many furnaces are now making it into "granulated slag." The molten slag is run into a large cistern, and as it pours into it from the end of a trough it is met by a stream of water forced under pressure through a flat nozzle, and the action causes the slag to fly into fine particles somewhat resembling coarse sand. It is then dug out of the water with a clam-shell dredge.

The product varies from sharp, hard and heavy, resulting from vitreous slag operated on with an excess of water, to soft, light and pummice-like, resulting both from too little water in the treatment, and from lime slag. The former kind makes an excellent ballast for yard work and on any tracks with moderate travel. It is easily worked and stays where it is put and has little dust. The soft kinds, however, should be avoided as they are liable to set, although, to be sure, it will even then drain and do its full duty as ballast so long as it is not necessary to disturb it.

John V. Hanna, C. A. Paquette, C. H. Byers, A. Q. Campbell, L. F. Goodale, G. D. Hicks, B. C. Milner, J. O. Osgood, F. W. Ranno, Samuel Rockwell, J. G. Sullivan, Committee.

TIES.

Your Committee submits herewith the revised general specifications for ties.* Under woods to be used without treatment, "locust" has been qualified as "locust, excepting the honey locust." Black cherry has been added. The first sentence of the first paragraph under "Dimensions," has been changed to read: "Except in pole ties with rounded sides or with half-round ties, none shall be less than 8 ins. width of face," etc. The second paragraph has been changed similarly. These changes have been made to comply with the proposed definition of "face" and to include half-round ties.

As directed by the Board of Direction, we have collected information regarding the sizes of ties now in use. The replies show a very large number of railroads are using 6 × 8 × 8 ties (6 × 8 ins. × 8 ft.) with satisfactory results. The objection to this size is based on two points—one the insufficient thickness for a 5½-in. spike; the other, insufficient strength as a beam to properly distribute the load. The first objection will be met when we adopt a more efficient and mechanical method of fastening the rail; the other is largely governed by the weight of the rolling load and character of the roadbed and ballast.

MAKING TIES.—Mr. Edwin F. Wendt has called attention to the experience of the Pittsburg & Lake Erie Railroad with galvanized steel nails which after three years' service in the Pittsburg Terminal yard at McKees Rocks had rusted so badly as to make the date entirely illegible. They have therefore substituted copper nails. The quality of the galvanizing seems to be poor, failing to meet the proposed specification. The Committee has no data to determine what life should be given by a well-galvanized steel nail, but is endeavoring to secure such information and in the meanwhile considers it wise to adopt the specification which is in use by the Western Union Telegraph Co. and the American Telephone & Telegraph Co. for galvanized wire.

The nail shall be of the specified size, made of steel, galvanized with a coating of zinc, evenly and uniformly applied, so that it will adhere firmly to the surface of the steel. Any specimen shall be capable of withstanding the following test: The sample shall be immersed in a standard solution of copper sulphate for one minute and then removed, immediately washed in water thoroughly, and wiped dry. This process shall be repeated. If, after the fourth immersion there is a copper-colored deposit on the sample or the zinc has been removed, the lot from which the sample was taken shall be rejected.

The standard solution of copper sulphate shall consist of a solution of commercial copper sulphate crystals in water. This solution shall have a specific gravity of

*Engineering News, March 24, 1904.

1.185 at 70° F. While a sample is being tested, the temperature of the standard solution shall at no time be less than 69° nor more than 70° F.

PRESERVATIVE TREATMENTS.—There is comparatively little to report as to preservative processes or the results of treatment. So far as known, there has been one new treating plant built during the year in the United States and one in Mexico. No new treatments worthy of special note have been proposed. One plant is now treating ties in this country by the Ruetgers zinc-creosote process. Practically all ties treated have been by the use of zinc-chloride. The records of the past year confirm the now prevailing opinion that treatment of cross-ties is necessary, desirable and profitable. Greater expense in higher-priced chemicals will produce greater life of the tie, but any of the usual treatments will prove profitable.

The Atchison, Topeka & Santa Fe Ry., has presented the results up to Jan. 1, 1904. Up to that date they had used 9,068,105 ties. No accurate records are obtainable prior to 1897, but since then it is understood the records are as nearly correct as can be expected. The average life of all the ties removed since then is 10.6 years. During 1903, there were removed from tracks 3,278 ties out of 111,503 which had been treated in 1885, 18 years previous. From 1897 to 1903 there were removed 56½% of the ties treated in 1885. Of the 270,581 ties treated in 1897, 3.7% have been taken out. Of 648,184 treated in 1898, 1.7% were out. The ties referred to were treated by the zinc-tannin process.

In 1892 there were laid certain experimental ties on the Western Division of the Pittsburg, Fort Wayne & Chicago Railway. These were untreated white oaks, and tamaracks and hemlocks treated by the zinc-tannin process. Their life record can now be given in full, as all are out but 25 of the hemlocks, which are to come out during the following summer.

Location.	Kind of Ties.	Ballast.	Date Laid.	No.	No. Removed on Account of Decay. 1897	1898	1899	1900	1901	1902	1903	1904	1905	Total.
Hanna.....	Treated Hemlock	Rock	1892	200	1	4	6	....	39	38	29	58	25	200
Hanna.....	Untreated White Oak	Rock	1892	200	....	....	8	46	26	9	45	66	....	200
Kosciusko..	Treated Tamarack	Gravel	1892	200	....	....	2	71	84	43	....	....	....	200
Kosciusko..	Untreated White Oak	Gravel	1892	200	....	....	2	27	73	71	27	....	....	200

Giving an average life, respectively, of 10.71, 10.17, 8.84 and 9.47 years.

The Chicago & Eastern Illinois Railroad began the use of red oak ties treated by the zinc-tannin process in 1899. They have put into track to date about 845,000 ties, of which 64 have been taken out of track. With untreated red oak probably nearly all of the first year's ties would now be out.

We have recently received a copy of a report on a test to determine the relative durability of sawed and hewed ties. The Missouri Pacific Railway, in 1893, laid, in Western Kansas, 14,081 sawed and 3,950 hewed long-leaf yellow-pine ties. After seven years 67½% of the sawed ties and 47.3% of the hewed ties were still in service. It is understood the sawed ties were practically all heart, while the hewed ones were pole ties, with unhewed sides. They were made with a full 8-in. width of face, however, so that the sap on the sides was in addition to the required width.

TIE RECORDS.—To secure correct records of the use of ties, there must be care and attention given to securing correct returns from the section foreman. We accordingly submit instructions for marking and reporting ties laid and removed.

Section foremen are provided with daily record blanks having space for each day of the month to record the number of treated ties put into track that day and the number taken out the same day, the latter being divided according to the cause necessitating their removal, whether rotten, broken, burned or rail cut. The section foremen must make these records each day. They must also show the year in which these ties were treated as indicated by the stamp and by the dating nail. These records must be entered up each day, and at the end of each month the daily record must be forwarded to the proper superior officer. If no treated ties have been taken out or put into tracks during the month, section foremen must so note on report.

Treated ties already in track, but taken up and relaid on another part of the same section, need not be inserted on this report as ties taken out or put in.

Section foremen must see that a dating nail is driven in the upper side of every treated tie when it is first laid in the track, about ten inches inside of the rail, and on the line side of the track. The tie shall be laid with the end having the year stamped on it on the line side of the track. A supply of these nails must be carried on the hand-car whenever any ties are to be laid, and dating nail must be driven the same day the tie it put in.

Foremen must be especially careful to see that neither they nor their men injure or destroy the marks or nails intended to identify the ties.

At the end of each year all dating nails for that year remaining on hand and unused must be returned to the storekeeper, and requisition made for a new supply stamped with the following year.

It is recommended by the Committee that, in addition to the use of the dating nail, each tie be stamped at the treating plant, before treatment, with the year; and, preferably, be stamped on both ends.

Your Committee recommends that the Association adopt the definitions of cross-tie, half-round tie, heart tie and face.

That the specifications, as amended, be adopted.

That the rules for tie records be adopted.

That the method of stamping, in addition to the use of dating nail, be adopted.

Also that ties treated with mineral salts be seasoned four to six weeks before being laid in track.

E. B. Cushing, W. W. Curtis, O. M. Dunn, C. F. W. Felt, E. Ford, R. R. Hammond, E. E. Hart, F. T. Hatch, W. K. Hatt, J. C. Nelson, S. M. Rowe, H. R. Safford, Committee.

BUILDINGS.

WAITING ROOMS.—Your Committee requests that the Association approve the use of one general waiting room for a local passenger station, without reference to separate waiting rooms for colored people.

ROUNDHOUSE.—Your Committee recommends that a modern roundhouse be designed and equipped as follows:

(1) That the form be circular and that the locomotives stand in the house normally with the tender toward the turntable.

(2) That distance from center of turntable to the inner side of roundhouse shall be determined by the number of stalls required in the full circle. That length of stall along center line of track should be not less than 85 ft. in clear.

(3) That clear opening of entrance doors should be not less than 12 ft. in width and 17 ft. in height. That the angle between adjacent tracks should be an even factor of 180°, so that the tracks at the opposite ends of the turntable will "line up" with it.

(4) The turntable should be not less than 75 ft. in length, to be operated by power, preferably electric.

(5) The material used in the construction of the house should be non-corrosive, unless proper care be taken to prevent corrosion.

(6) Engine pits should be not less than 60 ft. in length, with convex floors, and with drainage toward the turntable. The walls and floors may be of concrete, and proper provision should be made in construction for the support of the jacking timbers.

(7) Roundhouse doors should roll or fold and be made of non-corrosive material, unless the cause of corrosion be removed.

(8) Smokejacks should be fixed, having large hoods; constructed preferably of non-corrosive material and supplied with dampers. The cross-section of the stack should be not less than 30 ins. diameter.

(9) The floor should be of vitrified paving brick laid flat on a concrete foundaton and grouted. It should be crowned between pits, and that part adjacent to pits within jacking limits should be of wood.

(10) Drop pits should be furnished for handling truck wheels, driving wheels and tender wheels. These can be most economically constructed in pairs.

(11) The building should be heated with hot air by the indirect method, and the supply should be taken from the exterior of the building (no recirculation of air should be allowed). The air should be delivered to the pits under the engine portion of the locomotive. Air ducts should be located under the floor and special precaution should be taken to keep them dry.

(12) As much light should be obtained from the exterior of the building as good construction will allow.

(13) There should be an arc light, and a plug outlet for incandescent lights in each space between stalls.

(14) The contents of boilers should be taken care of and discharged outside of the building in a suitable receptacle and the heat units used as may be deemed best.

(15) Cold water should be supplied at each alternate space between stalls from an outlet not less than 2½ ins., located at a point about opposite front end of firebox; the water pressure should be not less than 80 lbs. The hydrants should be located below the floor in properly constructed pits amply drained. Modern practice requires the use of hot water in the maintenance of boilers.

(16) Compressed air is used for mechanical hoisting and blowing operations. Overhead outlets should be furnished in each space between stalls opposite front end of firebox. The pressure should be from 80 to 100 lbs.

(17) A modern roundhouse should have facilities for the location of a few necessary machine tools, preferably electrically driven.

(18) Air hoists, or portable gooseneck cranes with differential blocks, on wheels, should be furnished for handling heavy repair parts.

(19) The turntable pit side walls should be of concrete with wooden coping not less than 6 ins. thick, and the ties under the circular rail should be supported on concrete walls. Pivot masonry may be of concrete with stone cap.

A. R. Raymer, E. DB. Brown, B. C. Gowen, E. C. Macy, L. D. Smith, H. M. Steele, Committee.

MASONRY.

CONCRETE AND REINFORCED CONCRETE.—The Joint Committee on Reinforced Concrete consists of nine voting members of the American Society of Civil Engineers, four of the American Society for Testing Materials, three of the American Railway Engineering and Maintenance of Way Association, and two of the Association of Portland Cement Manufacturers. This Joint Committee has held two meetings during the year. A sub-committee on "Plan and Scope" will soon make its report, after which the experimental work of the committee will begin. This work will require generous financial and co-operative aid, and the Joint Committee should receive the hearty support of this Association. The following paragraphs are taken from the preliminary draft of the report of the sub-committee on "Plan and Scope" and are presented as indicating somewhat the lines along which the work of the Joint Committee will probably be done.

"Reinforced concrete is comparatively new, but it has already become of great importance in engineering and architectural construction. The development of the Portland cement industry and the improvement of the product and the rapid extension of the use of concrete are among the noteworthy features of engineering progress in recent years. It is not too much to say that with the increased demand for permanence and better appearance in structures a very great extension of the use of reinforced concrete may be expected in the next few years. However, to insure this development and to promote safe construction, a full knowledge of the properties and principles appertaining to reinforced concrete is needed. It is no reflection to say that our knowledge of reinforced concrete is imperfect. The very newness of this construction explains the paucity of information and diversity of opinions concerning it. But the lack of information and of experience in this work and the carelessness or temerity of inexperienced or incompetent persons make the danger from accident and failure of structures very great. The importance of securing definite and complete knowledge of the principles underlying reinforced concrete construction before a serious accident caused by imperfect or improper construction injures the standing of reinforced concrete, is too apparent to need argument. Besides, the properties of concrete are not as regular or as well defined as those of such materials as structural steel, and the composite structure of steel and concrete may be expected to have a different action from that of the individual components. Recent investigations, too, seem not to confirm certain deductions considered by many to have been established. The need of a thorough and comprehensive investigation of the properties of reinforced concrete and of the principles underlying its design and construction is evident, and the sub-committee recommends that such an investigation be undertaken under the auspices of the joint committee and emphasizes the importance and timeliness of such action to the engineering and constructional interests of the country.

It is true that many tests have been made on reinforced concrete, and valuable information doubtless exists. At the same time there is considerable diversity in results and in their interpretation. These conflicting opinions extend to so many features and even to such fundamental principles that it seems best to begin with elementary matters and to get at the subject from the foundation up. As the investigation proceeds the conditions accompanying tests already made may be more accurately learned and trustworthy data of such tests collected, and the collation of this information may be made a valuable part of the undertaking. However, the main purpose of investigation should be to establish principles independently of existing opinions, or of preconceived ideas, and the principal present use of existing available data will be to direct the nature and scope of the work and to avoid unwarranted assumption.

The scope of the investigation will include both (a) the determination of fundamental principles and properties, and (b) the choice of the main general conditions and requirements controlling the more common designs and construction. The above distinction is not intended to imply that the conditions and requirements of design and construction are not dependent upon principles and properties, but rather that, as the investigation proceeds, the results may be utilized without waiting for the completion of the work outlined, and that in the selection of the order of the work to be undertaken the choice should be such that items of probable immediate applicability will be taken up first. This attention to the order of the tests is warranted by the desire of railroad and structural men to get facts upon which to base construction at as early a day as possible. At the same time it must be borne in mind that the bearing of facts and experiments upon important fundamental principles may not be recognized in advance and that care must be taken not to prejudice results nor to base conclusions on insufficient evidence. Besides, if this investigation is worth undertaking, the subject-matter is worthy of comprehensive treatment and the Joint Committee cannot afford to stand sponsor for a superficial investigation.

The plan is to have tests made in the laboratories of engineering schools, railroads, etc., which have facilities for the work and which upon consultation express willingness to co-operate. It is expected that much of the work will be done as thesis work by senior engineering investigators. Certain expenses will be defrayed from funds raised by the Committee on Ways and Means. Tests along special lines may require that special arrangements be made, and special apparatus may have to be provided. A committee to be known as the Committee in Charge of Tests will supervise the work.

It is proposed by the plan to take up at the beginning the more simple constructions and the more fundamental principles and basic properties. Especial attention will be given to reinforced concrete beams, though columns and slabs will be taken up and plain concrete will be investigated to determine its properties and constants so far as they have a bearing upon reinforced concrete. Among the problems, variations, and determinations for reinforced concrete beams included in the scope of the work are the following: Amount of reinforcement; form, size and position of reinforcing bars; variety and consistency of concrete; carefulness of concrete making; repetition of load; manner of application of load; form of section; resistance to shearing; efficiency of devices and arrangements to resist shear; bond and anchorage; effect of age; general investigation of manner of failure and of the critical or controlling condition upon which the design of beams should be based. It will be seen that emphasis is placed on the stress-deformation relation, as

this has so important a bearing on the action of reinforced concrete beams.

The scope of the work may be modified and extended as the development of the investigation warrants. Special problems coming up may need attention. It may be well in the report of the committee to formulate general regulations for the proper execution of work in reinforced concrete construction. It should be stated that the plan contemplates tests of reinforced concrete, using that term to mean a construction composed principally of concrete and having a small amount of metal so imbedded as to take the principal tensile stresses and perhaps the secondary tensile and shearing stresses developed, but not to any great extent the compressive stresses, and does not include what may be termed steel-concrete, meaning thereby steel structures encased in concrete and using the concrete principally for stiffening and protection.

THE ADAPTABILITY OF CONCRETE TO CERTAIN POSITIONS IN RAILWAY CONSTRUCTION. — Your

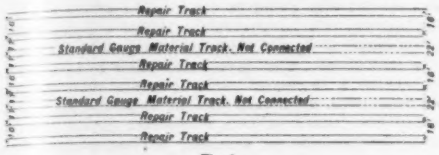


Fig. 1.

Fig. 2.

Fig. 3. (Heavy Repairs)

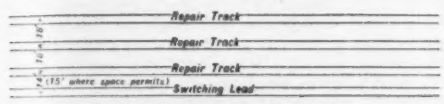


Fig. 4. (Light Repairs)

Figs. 1 to 4. Plans for Car Repair Yards.

Committee has made some investigations of present practice in order to present recommendations as to the efficiency of concrete backing for stone face work; as to imbedding large stones in interior of heavy concrete structures; as to use of concrete under bridge seats in place of stone pedestals, and economy and advisability of substituting reinforced concrete for the common forms of construction for small openings. To this end circulars were prepared and mailed to most of the railroads represented in the Association. A summary of the information with recommendations follows:

1. Efficiency of Concrete Backing for Stone Face Work. There seems to be no question as to the efficiency of concrete backing for stone face work, but as a combination structure is more expensive than a straight concrete structure, it is desirable to combine the two only under certain conditions. Where sufficient care is taken, it seems that no difficulty is experienced in securing a satisfactory bond between a stone face and a concrete back. The best result is obtained from a wet concrete.

As this is not a form of construction to be adopted because it is superior in any way to either stone or concrete masonry, but is a form which may be desirable and successfully applied under certain conditions, your Committee can only recommend methods of procedure with which satisfactory results can be obtained. Therefore we recommend that in this form of construction the face work be constructed after the usual manner, the back being left as rough as possible. To make the bond between the face and back more certain, headers should project well into the concrete. The work should be constructed in courses, and the backing brought up flush with each course of face stone.

Portland cement concrete made in accordance with the standard specifications of this Association, is recommended for this form of construction. The concrete must be sufficiently wet to conform readily to the rough contact surface of the stone facing.

2. Imbedding Large Stones in Interior of Heavy Concrete Structures. This is not a very common practice among railway engineers, because conditions seldom exist that favor, from an economical standpoint, this form of construction. The feeling seems to be that in massive work, where weight is more of a factor than strength, rubble concrete can safely be used; therefore, in such work the question would resolve itself into one of comparative cost.

Apparently one point of weakness in this form of construction is the fact that it is difficult to place the rubble stone so that the joints will be broken. Wet concrete is favored for this form of construction, as it is easier to force it to conform to the outline of the rubble stone, and a more perfect bond between the two materials is obtained. That the rubble stone should be placed a sufficient distance apart to permit perfect tamping of the concrete seems to be an important factor. Also that the relative size of the rubble stone to the thickness of the wall is a point that would receive serious consideration.

Your Committee recommends the use of rubble concrete wherever a saving would result, provided the wall or structure in question is not less than 4 ft. thick. The greatest diameter of the rubble stone must not exceed half the thickness of the wall or structure. The rubble stone should be drenched, before placing, and care must be exercised to avoid continuous vertical joints. The concrete must be sufficiently wet to conform readily to the rough surface of the rubble stone, but not so wet as to permit the segregation of the rubble stones. The thickness of the concrete between the rubble stone and the exterior of the wall must not be less than one foot. The rubble stones should be placed on their natural bed, and the minimum distance between them must not be less than six inches.

3. The Use of Concrete Under Bridge Seats in Place of Stone Pedestals. Concrete has been and is being used extensively and successfully under bridge seats, there not being a single case reported where concrete bridge seats failed to do the work expected of them. They have been successfully used in bridges up to 200-ft. span. They are successfully constructed from the same grade of concrete as used in the pier or abutment, except that a smooth finish is obtained by the use of a cement and sand mortar on the top.

We recommend the use of concrete bridge seats under all ordinary conditions where the body of the pier or abutment is constructed of concrete, using a slightly richer mixture in the coping than in the body of the structure. A Portland cement concrete made in accordance with this association's standard specifications is recommended. The work should be continuous, no time intervening between finishing the body of the structure and placing the bridge seat. The bridge seat should be finished on the top with a mortar composed of 1 part Portland cement and 2 parts sharp sand and trowled smooth. This top finish should never be less than 1 in. thick.

4. Reinforced Concrete for Small Openings. This form of construction for small openings seems to have many points of advantage to its credit, among them, ease of construction, low first cost, durability, etc. The value of the concrete arch constructed of plain or reinforced concrete is well known, and is usually preferred wherever the conditions will permit of its use. The use of the flat-top structure is more limited than that of the arch, but because of the economy with which it may be constructed and the limited head room required, it is a very convenient and desirable form, and it occurs to your Committee that it is a form with great possibilities.

There are certain forms of I-beam construction in which the I-beams carry the load and the concrete protects the metal from corrosion, that should not be classed as reinforced concrete. Such construction, although very effectual, consumes a large surplus of metal, and therefore is not economical. There is little room for doubt as to the question of economy of straight reinforced concrete structures compared with the common form of construc-

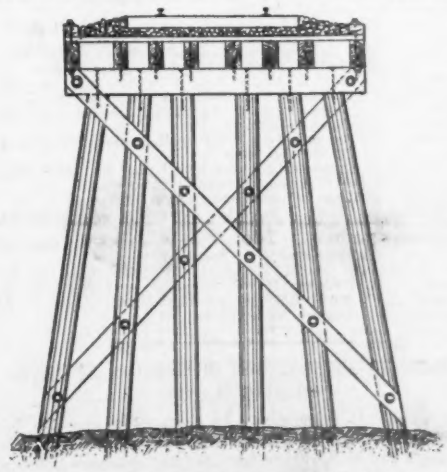


Fig. 9. Design for Trestle with Solid Floor.

tion for small openings. We also think it advisable to substitute reinforced concrete for the common forms of construction for small openings, but think the flat-top structure should be studied in detail and an approved form recommended for the consideration of the Association.

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YARD AND TERMINALS.

CAR REPAIR YARDS.—Heavy car repair tracks should be under cover, and provided with overhead cranes, to facilitate heavy lifting. They should preferably be short, of a capacity of ten to twenty cars each and arranged in pairs; The tracks of each pair should be spaced 16 ft. c. to c., and the pairs 40 ft. c. to c. Other spacings and suggestions are shown in Figs. 1 to 4.

TEAM DELIVERY YARDS.—These yards should be located convenient to the freight house, so that the receipt and shipment of freight may be easily under control of the freight agent's force. The tracks should be arranged in parallel pairs; the tracks of each pair should be spaced 12 ft. c. to c., and the pairs themselves 48 ft. c. to c.

The yard should be provided with a crane for loading and unloading heavy freight. Additional tracks should be provided adjacent to a considerable ground area, where derricks can be located and material unloaded and piled

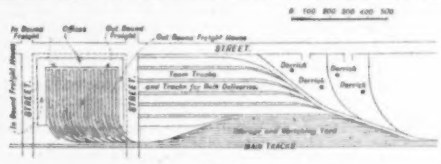

Fig. 5.

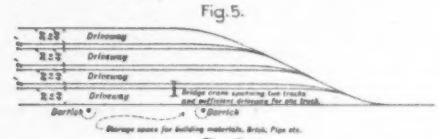

Fig. 6.

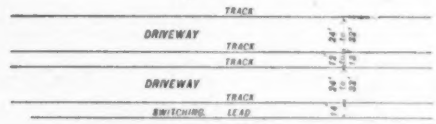

Fig. 7.

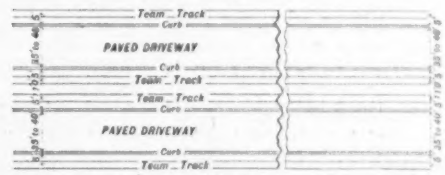

Fig. 8.

Figs. 5 to 8. Plans for Team Delivery Yards.

ready for delivery by team. Such a layout is very desirable in handling building material for large buildings, and also for unloading and liberating cars which otherwise might have to be held under load for various causes. The driveway should be paved with gravel or broken stone for ordinary work, but where there is much trucking it should be paved with stone blocks. Some smooth pavement, such as brick, may be employed for sanitary reasons, where large quantities of perishable freight are handled.

It is desirable to limit the length of team tracks to about 20 cars capacity to facilitate switching operations. They should be stub-ended at a main driveway connecting all the other driveways. Wagon scales should be provided handy to team entrance to yard; and track scales should be provided and located for convenient switching. Different types of team delivery yards, suggested by members of the committee, are shown in Figs. 5 to 8.

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WOODEN BRIDGES AND TRESTLES.

Wooden bridges and trestles have served their purposes, and while in many cases they have been superseded by permanent construction, it will be a very long time before wooden trestles cease to be used. The specifications for trestle timber have been compiled after comparing standard specifications from all parts of the country. The Committee has endeavored to eliminate those specifications that were needlessly exacting or calling for the impossible.

A plan (Fig. 9), for a ballasted deck trestle is submitted without dimensions. Local conditions and varying unit stresses will determine many of the sizes and details, but your Committee believes that the type shown is best, keeping in mind the fact that repairs must be made in time. Treated timber is to be used throughout.

Specifications for workmanship are submitted. It is not expected that they will be universally adopted, but rather that they will indicate good average practice and that their use will lead to close and accurate fit among the members, and that when built under these specifications each member will carry the load designed for it.

SPECIFICATIONS FOR BRIDGE TIMBER.

GUARD-RAIL. (Long leaf yellow pine or Douglas fir.)—To be cut from sound live trees and sawed full size, square in section and out of wind. It shall be close grained and free from wind shakes, unsound knots or knots over 2 ins. in diameter, or any defect that will impair its strength or durability. One face shall show all heart, the other face and both edges shall show not less than 75% heart measured across the surface anywhere on the piece.

BRIDGE TIES. (Long leaf yellow pine and white, post

and burr oak.)—Cut from sound live trees sawed full size, square in section, and out of wind. Timber shall be close grained, free from wind shakes, unsound knots, or knots over 1½ ins. in diameter, or any defect that may impair its strength or durability. Sap will be allowed on any or all corners, but each side shall show 75% heart, measured across the side anywhere on the tie. Sound knots not more than 1¼ ins. in diameter will be allowed if so located that they will not impair the strength of the tie.

BRIDGE TIES. (Douglas fir.)—Shall be full size and length and sawed square and out of wind. They must be close grained and free from wind shakes, large, loose or unsound knots or decayed streaks, and must show at any point in their length not less than 85% heart. Knots must not show over 2 ins. in diameter as measured on the surface and must not be in groups.

STRINGERS. (Long leaf yellow pine).—To be cut from sound live trees and sawed full size, square in section and out of wind. They must be close grained and free from wind shakes, large or unsound knots, pitch seams, decay or defects that will impair their strength or durability. No side to show less than 85% heart, measured across the sides anywhere in the length of the stick. Solid knots will be allowed, but not in groups nor so located as to impair the strength of the piece.

STRINGERS. (Douglas fir.)—Shall be sawed square in section and full size and length. Straight close grained and cut from sound live trees and must be free from shakes, large, loose or rotten knots, pitch seams, pitch pockets, or any other defect in the grain which would impair the strength of the piece. Sap wood, if sound, will be permitted on two corners of the stick, but at least 85% of any face and 70% of any edge shall show all heart measured across the surface at any point on the length of the stick. Sound knots less than 2 ins. wide will be permitted if not less than 4 ins. from the edge. Knots must not be in groups, and in no case will they be allowed on any edge of any stick.

CAPS, INTERMEDIATE CAPS AND SILLS. (Long leaf yellow pine, white, post and burr oaks.)—Shall be cut from sound live trees, sawed full size and length and square in section. Timber shall be close grained and free from wind shakes, large or unsound knots, decay or any defects that will impair its strength. Solid knots will be allowed, but they must not be so located as to impair the strength of the stick. The opposite or bearing faces of the caps shall show 85% heart and the other two sides shall show 75% heart, measured across the face anywhere in the length of the stick.

CAPS, INTERMEDIATE CAPS AND SILLS. (Douglas fir.)—Timber shall be sawed full size and length, square in section and out of wind, close grained and free from wind shakes, large, loose or unsound knots, decayed streaks, or hollow butts. Sap wood if sound will be allowed, but each face shall show at least 75% heart measured across the face anywhere in the length of the stick. Sap must not exceed 2 ins. in width at any corner. Knots must be sound and not over 3 ins. diameter measured on surface of stick and must not be in groups.

POSTS. (Long leaf yellow pine, white, post and burr oaks, Douglas fir.)—Timber shall be cut from live sound trees, sawed full size and length and out of wind. It shall be free from shakes, large or unsound knots or any defect that will impair its strength or durability; each face must show 66% heart measured across the face anywhere in the length of the stick. Sound knots will be allowed up to 2 ins. diameter, measured on surface of the stick, but no knots will be permitted in the corner of the post. One-inch wane will be allowed on two corners half the length of the stick.

LONGITUDINAL STRUTS OR GIRTS. (Long leaf yellow pine, Douglas fir.)—Timber to be cut from sound live trees and full size and length, square in section and out of wind. It shall be close grained and free from shakes, rot and any defect that will impair its strength or durability. One edge shall show all heart, the other three sides shall show 85% heart measured across the face anywhere in the length of the stick.

LONGITUDINAL X-BRACES, SASH BRACES AND SWAY BRACES. (Long leaf yellow pine, Douglas fir, white, burr or post oak.)—To be cut from sound live trees, sawed full size and length and square in section, close grained and free from wind shakes, large or unsound knots or other defects that will impair its strength for the above pieces, each face to show 60% heart anywhere in the length of the stick; no restrictions as to sap on edges.

PILES. (White, post or burr oak.)—Piles shall be cut from growing trees, free from wind or heart shakes, large or unsound knots, decay or other defects that impair the strength or durability of the pile. Only butt cuts, cut above the ground swell of the tree, will be accepted. Bark shall be peeled off, and knots trimmed smoothly to the body of the tree. After peeling and trimming, piles shall be reasonably straight and uniformly tapering. Piles shall be close, firm grain and with saping not over 2 ins. thick. They shall not be less than 12 ins. diameter 6 ft. from the butt, and when less than 30 ft. in length shall be 10 ins. diameter at the point, 30 ft. to 39 ft. long, 9 ins., and 40 ft. long and over, 8 ins. at the point. Square piles shall be of timber squared throughout their entire length, smoothly hewed and of the following dimensions: Large end not less than 14 ins. or more than 16 ins. in diameter, small end for piles 30 ft. long and under 10 ins. square; 30 ft. long to 40 ft. long, 9 ins. square; 40 ft. long and over, 8 ins. square. A pile will be considered straight if it has not more than 2 ins. deviation from the straight in 20 ft., 5 ins. in 30 ft., or 8 ins. in 40 ft., or 10 ins. in 50 ft., but no short crooks will be allowed.

PILES. (Norway and tamarack.)—Piles shall be cut from growing trees, free from wind or heart shakes, large or unsound knots, decay or other defects that impair the strength or durability of the pile. Only butt cuts, cut above the ground swell of the tree, will be accepted. Bark shall be peeled off, and knots trimmed smoothly to the body of the tree. After peeling and trimming, piles shall be reasonably straight and uniformly tapering. Piles shall not be less than 14 ins. nor more than 18 ins. diameter at the large end. Piles less than 36 ft. long shall be not less than 10 ins. diameter at the small end. Piles over 36 ft. long shall be not less than 9 ins. diameter at the small end.

PILES. (Long leaf yellow pine.)—Piles shall be cut from sound live trees close grained and free from wind or heart shakes, large or unsound knots, decay or other defects that will impair the strength or durability of the pile. No doubtful grades of yellow pine will be accepted. Piles shall be hewed square, except that 1 in. wane will be allowed on two corners half the length of the pile. They shall not be less than 12 ins. nor more than 14 ins. at the large end and not less than 8 ins. square at the small end. Piles having a bend not exceeding 4 ins. in 20 ft., 6 ins. in 30 ft., and 8 ins. in 40 ft. or over will be considered straight. No short crooks allowed. Piles must be hewed smoothly without deep score hacks. Piles shall show at least 75% heart on face anywhere in their length.

PILES. (Red or white cedar.)—Piles shall not be less than 14 ins. diameter at the large end and 9 ins. the small end, if less than 30 ft. in length; when over 30 ft. in length they shall be not less than 8 ins. in diameter at the small end. Unsound butts will be accepted if the defect is not more than 4 ins. diameter. There must be 5 ins. of sound close grained wood all round the defect. Red cedar piles must fulfill above conditions, but shall not be less than 12 ins. diameter at the butt. Piles shall have knots trimmed smoothly to the body of the tree. Piles having a bend of 4 ins. in 20 ft., 6 ins. in 30 ft., and 8 ins. in 40 ft. or longer will be considered straight.

PILES. (Oregon fir.)—Piles to be made from straight, sound, live red or yellow Oregon Fir, free from shakes or unsound knots, and showing not more than 1½ ins. of sap at the small end. Piles shall show a gradual taper from end to end. Ends must be cut off square, all bark peeled off and all branches and knots trimmed off smoothly. Piles under 40 ft. in length must be not less than 10 ins. diameter at the small end and not less than 14 nor more than 18 ins. diameter at the large end. Piling over 40 ft. in length shall be at least 8 ins. diameter at the small end and from 16 to 22 ins. at the large end. Piles will be considered straight when they have a gradual bend of 2 ins. in 20 ft., 3 ins. in 30 ft., 4 ins. in 40 ft., or 5 ins. in 50 ft. or over.

PILES. (Cypress.)—Piles shall be cut from sound heart, red or swamp cypress, close grained, free from unsound knots, decay or large pecky timber or any defect that would impair the strength or durability of the timber. Piles shall be squared throughout their whole length and smoothly hewed. No piles to be more than 16 nor less than 14 ins. square at the large end. Piles less than 30 ft. long shall be 10 ins. square at the small end. Following bends will be considered straight: 2 ins. in 20 ft., 3 ins. in 30 ft., 4 ins. in 40 ft., 5 ins. in 50 ft. Piles shall be free from sap.

FOUNDATION PILES.—Piles for foundation that will always be completely submerged and piles for cofferdams, false work and other temporary work may be of red oak, hickory, elm, gum or any sound timber that will stand driving and need not be peeled. They must not show short crooks. A line passed from end to end of the pile shall lie within the pile. Such piles shall not be less than 12 ins. nor more than 16 ins. diameter at the large end and at least 9 ins. in diameter at the small end.

SPECIFICATIONS FOR WORKMANSHIP FOR PILE FRAME TRESTLES.

The work shall be done in strict accordance with the plans furnished.

Piles shall be properly prepared and driven to the satisfaction of the engineer.

When necessary the heads of the piles shall be protected by rings and the points by iron or steel shoes of approved pattern.

Piles shall generally be driven until they do not sink more than ¼-in. per blow for the last ten blows of a hammer weighing 3,000 lbs. falling freely 15 ft. except in soft bottom, when special instructions will be issued.

Batter piles shall be driven at the desired inclination, so as to require but slight movement before framing.

The tops of the piles in the same bent shall be sawed off to the same plane and shall be trimmed to leave no horizontal surfaces projecting outside of the caps.

Piles shall be framed for a fair bearing to braces.

All piles injured in driving or driven out of place shall either be pulled or cut off and new piles driven.

Caps shall be sized over the piles or posts to a uniform thickness. They shall be drift bolted to the piles or posts.

Frame bents shall be neatly and accurately framed.

Sills shall be securely drift bolted to the foundations.

Posts shall be fastened to sills and caps by drift bolts or dowels and toe-nailed.

Bracing, both longitudinal and transverse, shall be secured to the bents by bolts and boat spikes.

Stringers shall be sized at the caps and shall be bolted together, using proper packing spools.

Stringers shall be in double lengths and shall be laid to break joints.

Each stringer shall have four packing bolts at each cap and one uncut stick of each group shall be drift bolted to the cap.

Side stringers and stringers laid singly shall be drift bolted at each end to the cap.

Ties shall be notched over stringers to a uniform thickness. They shall be spaced as shown on the plan.

Every fourth tie shall be spiked at each end to the outside stringer; the ties shall be bored for these spikes.

Guard-rails shall be neatly dapped 1½ ins. over the ties and secured by bolts or lag screws to every fourth tie.

The bolt or lag screws to be placed in the same tie which is spiked to the stringers.

Holes for bolts and drift bolts shall be bored to give a tight driving fit for the bolts.

Bolts shall be ordered of such length that not more than ½-in. of thread will project beyond the nuts.

Washers shall be of standard pattern.

Packing spools shall have the same area of bearing on timber as the washers for the packing bolts.

Bulkheads shall be of good old timber cut to the slope of the bank to hold the earth or ballast.

I. O. Walker, F. E. Schall, F. H. Bainbridge, D. B. Dunn, H. G. Fleming, B. W. Guppy, J. C. Haugh, H. S. Jacoby, C. C. Maillard, A. S. Markley, F. C. Miller, F. J. Stimson, Job Tuthill, Committee.

STANDARD ARRANGEMENT OF SIGNALS AT INTERLOCKING PLANTS.*

It is desirable that signals be arranged to give full information. So long as the track layouts were confined to single and double track junctions and crossings it was a comparatively simple matter to arrange signals so that the engineer would know what route was clear. The method of giving this information was not uniform; some roads gave the top arm for the route diverging to the right, the second arm for the route next to the left, the third arm for the route still further to the left, etc.; other roads gave the top arm for the straight route, the second arm for the route diverging to the right, and the third arm for a route diverging to the left; if there was one diverging route only, the second arm governed it. It is obvious that with a strict adherence to either of the above arrangements the top arm would in some cases govern a low speed or switching route and the lowest arm the highest speed route. This would require the engineman to have an intimate knowledge of each situation to run with safety.

As three, four and six track combinations were developed, the effort to give a separate signal indication for each route resulted in a multiplicity of signals confusing to the engineer, as many as six arms being required in some cases. Practice has demonstrated that the spacing should be not less than six feet to properly distinguish signals at a distance; this would require a mast of such great height that it would be dangerous unless of very expensive construction, and under many weather conditions the top arm would be out of sight of the engineer, especially if such mast were located on a signal bridge. Furthermore, it is a proved fact that while enginemen, when running at a high speed, may know at once the indications at a three-arm mast, they are confused when confronted with more than this number of arms. Even were it practicable to give a separate signal for each route, they should be arranged to signify permissible speed at which each route may be run.

The practice on some roads is to distinguish between freight and passenger tracks by placing the signals higher for the passenger track than for the freight; but as tracks are now used interchangeably for passenger and freight service this method is objectionable.

From the above we conclude that an arrangement of interlocked signals that shall give the number of routes and the direction of divergence from a main or nominally straight route is in many cases impracticable and insufficient when practicable, unless the signification of the speed at which movements may be made over each route is added.

This speed signification is made as clear as possible and at the same time logical; easily understood and easily explained to enginemen, by locating the signals governing the high speeds high on the masts, and the signals governing low speeds low on (or near) the masts. This places the high speed signals where (under nearly all conditions) they are most conspicuous, and keeps the low speed signals as much as possible out of the way; a very desirable arrangement, especially where both high and low indications must be given from the same point.

While the addition of a third high speed arm under certain conditions may be desirable, your committee is unanimous in its opinion that as a rule only two high speed arms should appear on one mast. The third arm may be useful where two lines diverge from opposite sides of the straight track, under the condition that all three lines are of equal importance and all operating high speed trains; the top arm would then relate to the straight track and would be (nominally at least) the highest speed route; the second arm would relate to the route diverging to the right, and the third or bottom arm would relate to the route diverging to the left; each arm would have its separate distant signal. Such an arrangement gives the enginemen information as to which of the two diverging routes is set, and this might prevent trouble if the operator made the mistake of setting the wrong route; but the engineman is supposed to take the route given him, because at such points trains are sent upon a particular route by the tower operator under orders from the dispatcher or under fixed rules. Your committee discussed the question of providing an indication for intermediate speeds, such as tonnage trains are required to make in a movement from main line to passing sidings, in order to avoid stalling, and to get out of the way of passenger trains promptly; this condition is provided for in this way: If the siding is provided with a long flat turnout, it should be signaled as a high speed diverging route, otherwise it must be governed by a low signal. It has become recognized as necessary to have long flat turnouts for important branch lines and long flat crossovers for the passage of trains from one main track to another main track in order to run around slower trains. We are of the opinion that one arm is sufficient to govern all diverging routes of this character; but they should be made with some restriction in speed and the lower arm implies this; the top arm always refers to the highest speed route.

The signals for low speed routes should be low and of dwarf construction, because it is not intended or desirable that they should be conspicuous at any great distance, and one arm is sufficient for all low speed routes signaled from one point. Conditions calling for an exception to this rule are so rare that they serve only to prove the rule. According to the present practice low signals are used for all low speed routes, except the ones where they are most needed, namely, movements from a main line in the established direction to a siding or spur or to another main line against the established direction; many accidents have resulted from the present practice of giving a high arm for this movement. We believe it is correct to govern every low speed route with a low signal.

Since it is the function of distant signals to give preliminary information regarding home signal indications, so that the speed of trains may be governed accordingly, a separate distant signal should be provided for each high

*From the report of the Committee on Signaling and Interlocking of the American Railway Engineering and Maintenance of Way Association; presented at the annual meeting in Chicago, March 21 to 23; J. C. Mock, W. C. Cushing, C. L. Addison, F. H. Alfred, C. Dunham, L. Griffith, A. H. Rudd, W. A. D. Short, T. S. Stevens, J. B. Taussig.

speed home signal. The present practice is to install distant signals for the highest speed only; with this arrangement trains given high speed diverging routes are required to run "prepared to stop" at the home signal; and the value of the high speed home signal is thereby decreased. Enginemen who are accustomed to get a high speed route regularly disregard this rule and interpret the caution indication relating to the highest speed to mean the "diverging high speed route is clear;" this is dangerous and the value of the distant indication is decreased, whereas in this day of high speeds the value of the distant indication should be increased and rigidly observed.

Our sixth recommendation in regard to the color stop indication and the position stop indication for all home signals is inserted here because there has developed recently a tendency to depart from the present almost universal practice. Your committee believes that red is so firmly established as the "color stop indication" and the horizontal position of the arm as the "position stop indication" that they should not be disturbed. Blue has been used as the color stop indication for low speed dwarf signals, governing movements from one side track to other side tracks or a main track, and has been suggested for all signals governing low speed diverging routes. The argument for this is:

(A) That it will not be mistaken for non-interlocked switch displaying a red light (the switch light does not necessarily mean stop).

(B) That it would serve to better distinguish between high speed and low speed signals, and between interlocked signals and automatic signals. It would also reduce the number of red lights that high speed trains would pass.

Some recent designs for automatic block signals show the vertical position of the arm for the stop indication. The American Railway Association has prescribed what the stop indication shall be, and we consider it proper to endorse their ruling and at the same time discourage any tendency to depart from it. There should be only one color and one position of the arm to mean stop.

While it is believed to be impracticable to present to the enginemen a mark of distinction conspicuous and easily memorized for all the various signals encountered on a division equipped with interlocking plants, station signals, train-order signals and automatic block signals, yet it seems very necessary to distinguish between home automatic signals past which at the stop indication trains may proceed under restrictions and other home signals requiring a stop until signal is cleared. Most roads have some sort of distinguishing mark for this purpose; for example, several use the automatic disk signal; this gives a decided contrast with the semaphore arm interlocked signals; one road points the ends of arms on automatic signals for contrast with square end on interlocked signals; another depends on a conspicuous number plate and the difference in general outline between the automatic signals and the interlocked signals. The above examples are sufficient for day time (or night when fortunate enough to have the aid of head-light); but on four-track roads with signals located on bridges, the head-light does not assist and the difference in outline no longer serves, since automatic designs are now used extensively for interlocked signals. One road has a system which requires every high interlocked signal to display two arms and two lights (the lower arm is frequently a "dummy"—not operative—since at many points there is only one route to be governed; in such cases it always displays a stop indication); this arrangement serves as a mark of distinction and reduces the chances of accidents due to an extinguished signal light; while this has its advantages, it falls short of a final solution of the question, because a broken glass will result in a "proceed" indication, where white is so used, and one light out obliterates the distinction between it and one-arm automatic signals. Where green is used for "proceed," yellow for "caution," and all automatic signals carry two arms (one home and one distant), this method has only two bad combinations in the possible total of eighteen: (1) red above green, which for an interlocked signal means "proceed" at second highest speed; such a combination at an automatic signal means stop (the distant arm is stuck at clear); (2) two green lights mean "all clear" for automatic signals. But for interlocking signals two green lights indicate that both distant arms are clear through some derangement.

One road has put on the automatic signal post an illuminated letter "A" as a distinguishing mark; the disappearance of this mark converts it into an absolute stop signal. It is presumed that lights at interlocking plants being under constant supervision and within the visual range of the leverman that an extinguished light is immediately discovered; for this reason the additional lamps should be carried by the automatic signals instead of the interlocked signals. Levermen frequently extinguish lights through rough handling of the levers and fail to notice it. A great many accidents have occurred at interlocking plants because of extinguished lights. A compromise suggestion to put an illuminated letter on all interlocked signals, locating it in such a way that it would not be mistaken or could not substitute a signal, was discussed by your committee, but failed to receive approval of the majority, so that while we recognize the importance of a distinguishing mark and of having this mark uniform for all roads, your committee has failed to agree on a specific recommendation, submitting a general one and pointing out the present variety in practice, hoping that the discussion may bring out one that can be adopted as standard.

Interlocked signals relate to the use of track within the limits of an interlocking plant. Where a block system is in force there should be signals placed at or near these limits to give permission to proceed beyond into the block. There are interlocking plants located between block stations that have no connection with them, being simply for the purpose of governing a local condition. But it is a coming practice to have block stations at such interlocking plants, and advance signals are installed. This facilitates traffic by permitting the use of the interlocking plant as soon as the train has cleared the advance signals. Where advance signals are omitted trains are liable through misunderstanding to enter a block; for example, when they receive the "proceed" indication from a low speed signal.

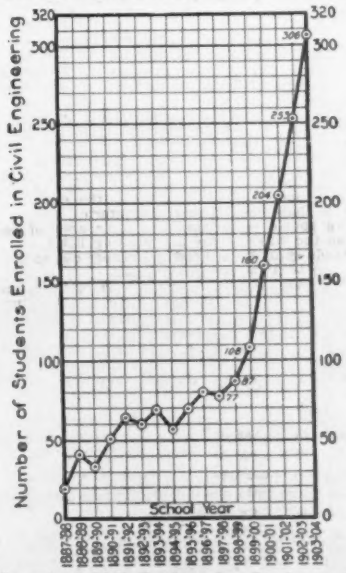
The Association has adopted the principle of continuous light for arm castings. This requires signal arms in the "proceed" position to be very close to the prescribed angle. From the Railway Signal Association's investigation of the subject of wire connected signals it is shown that they are not safe when operated more than 2,000 feet fect from levers, as it is then found impossible to get reliability and accuracy in varying temperatures with wire connected signals. Electric signals are coming to be extensively used for distant interlocking signals. Since the distant signal is used only in connection with high speed routes, they are required to be located 3,000 or 4,000 feet from the interlocking tower. At this distance the operation by means of pipe line would be very difficult and expensive. All high speed signals that are operated mechanically should have pipe connections. The low speed signals are usually not far from the operating levers and the movements they govern being secondary and slow, nothing serious can result from a varying of the stroke.

Where clear indication is received from a distant signal it means that trains may proceed at a high rate of speed, which should therefore insure that all home signals are clear as far as the next distant signal, or when a train receives a cautionary indication at the distant signal it should mean that he may encounter a signal at the stop indication before passing out of the limits of the interlocking plant.

Many plants have been installed without providing signals for reverse movements; so that when such movements are made, hand signals are required. This is incomplete signaling, and has led to many derailments. To be perfectly safe, every movement made at an interlocking plant should have an interlocked signal to govern it.

NOTES FROM THE ENGINEERING SCHOOLS.

PURDUE UNIVERSITY.—The School of Civil Engineering was established at Purdue University about 1886, and the first graduating class dated from 1887-88. The accompanying diagram shows the enrollment of civil engineering students from the time the course was established to and including the school year 1903-04. It is seen from this diagram that the enrollment fluctuated more or less, increasing slowly during the first ten years or so,



Enrollment of Civil Engineering Students, Purdue University.

then took a sharp upward turn, increasing from 77 in the school year 1897-98 to four times that number six years later. The enrollment (306) in 1903-04, was exceeded at but one other school (Cornell University with 312 civil engineering students). The enrollment for the current school year (1904-05), while not finally known until the issue of the annual catalogue, seems to follow the general rate of growth of the preceding four or five years. The graduates in civil engineering for several years past have numbered as follows: 1899-'00, 7; 1900-'01, 15; 1901-'02, 23; 1902-'03, 35; 1903-'04, 41. There are fifty in the present senior class in civil engineering. The course of studies was revised in 1900 with a view to provide a better balance in the students' preparation for the work of the civil engineer. The usual provision is made for the cultural subjects, including literature, language, economics, etc., and for the sciences, including physics, chemistry and geology. In the revision the series of railway engineering subjects was considered extended. Students who desire to specialize in sanitary engineering substitute for the advanced subjects in railway engineering, work in the sanitary examination of water and advanced design problems in sewerage, etc. About one-third of each senior class usually choose the sanitary subjects, receiving the same degree as the regular graduates. Somewhat more than 50% of each senior class enter railway engineering service after graduation. Underclass students very generally find vacation employment, usually as members of survey parties, but in numerous instances as laborers on concrete or other construction work, in bridge shops, on track gangs, as railroad yard clerks, etc. A constant effort is made to extend the scope of the lines of work engaged in by both graduates and underclass students.

The state legislature has just made an appropriation for a special Civil Engineering Building.

THE PASSAIC VALLEY POLLUTION LAW, in New Jersey, by which it was proposed to construct a huge trunk sewer to carry the sewage of Paterson, part of Newark and other cities on the lower Passaic watershed to New York Bay, has been declared unconstitutional by the highest court of New Jersey. The court based its opinion on the features of the law relating to the method of raising money by taxation for the work of constructing and maintaining the sewer. The court said in its opinion:

> The significant features of the taxing scheme are, first, that the amount to be raised is committed solely to the commissioners, within the limit of nine million dollars in the matter of construction, and without any limit in the matter of maintenance; second, that the tax is laid upon a taxation area that is not coterminous with the sewerage district established by the Legislature; and third, that neither the taxation area nor the sewerage district is a political division of the state, or invested with any governmental function.

On each of these grounds the court held the law to be unconstitutional.

A DISASTROUS BOILER EXPLOSION occurred on the morning of March 20, 1905, in the shoe factory of R. B. Grover & Co. at Brockton, Mass. As far as can be determined at the time of writing, at least 75 persons were killed. The building was five stories high, about 90 × 250 ft. in ground plan, and of timber frame construction. The boiler house was situated in the rear part about the middle of a long side of the building. It contained two boilers, one of which had been idle for some time and had been started again only the night before the explosion. It exploded a little before 8 a. m., when all employees were at work. Half the entire building was completely wrecked. The ruins caught fire, and soon the whole building was destroyed. Several smaller buildings nearby also burned down before the fire was controlled. The engine-runner in charge of the boiler-room at the time of the explosion was probably killed. The night watchman, who had been in charge of the boilers over night, while steam was being raised in the boiler in question, is reported as saying that at 7.20 a. m., when he left, the pressure in the boiler was 80 lbs. The boiler was insured by the Hartford Boiler Insurance Co., and was for this reason not subject to state inspection. The state authorities have taken charge and will endeavor to find out the circumstances and cause of the explosion. It is known that the boiler went almost vertically upward when it exploded. The fusible-plug has been found, and apparently was not melted out.

SIX BUILDINGS COLLAPSED DURING CONSTRUCTION in New York City on Sunday and Monday, March 19 and 20, 1905. All of them were flat-buildings, of the usual brick wall and timber floor construction. All five were either five or six-story structures, and had been completed either to the roof or to the next tier below. No persons were in any of the buildings when they fell, as most of the accidents occurred on Sunday, and on Monday a general caution prevailed among builders of structures of this class. A feature of the case is that the six buildings in question are not in the same immediate neighborhood, the two farthest apart being on opposite sides of the Harlem River, and about four miles from each other. The series of accidents is now under investigation. It is suspected that most of them were put up in disregard of the Building Code provision which says that no masonry work may be done when the temperature is below 24° F. Saturday, the day preceding the general collapsing fever, was the warmest day of the present season. Sunday followed with continued warm weather and rain. The first five buildings collapsed at 9 a. m., 2 p. m., 6 p. m., 11 p. m., and 11.30 p. m. Sunday, and a building adjacent to and continuous with the first one fell at 6 p. m. Monday. In each of the six cases, one or more walls failed on practically their full height.

TWO COAL MINE EXPLOSIONS occurred March 19, in the Rush Run and Red Ash mines near Thurmond, W. Va. In the first explosion 10 men were killed, and in the second explosion 14 men, forming a rescuing party, were killed. In both cases the miners were carrying naked lights. It is difficult to understand how any of the men in the rescuing party could have been so foolhardy as to enter the mine without carrying safety lamps. The two mines belong to the New River Smokeless Coal Co., and they are so connected as to form practically one mine. It is stated that 46 men were killed a few years ago by an explosion in the Red Ash mine.

THE PENNSYLVANIA RAILROAD PENSION DEPARTMENT reports that during the five years of its operation there has been authorized to be paid in pension allowances to the retired employees of the company the sum of $1,614,087.59, made up each year as follows: 1904, $390,000.00; 1903, $359,374.32; 1902, $328,403.10; 1901, $292,290.20, and 1900, $244,019.97. The above expenditure does not include the expenses of operation of the department, which is also borne by the company. During the five years application of the pension plan 2,418 employees have been retired as pensioners from the active service of the company, of which number 700 have died. Of the total number retired 568 were between the age of 65 and 69 years, of whom 439 were retired on their own request with the approval of the employing officer.

PERSONAL.

Mr. Robert R. Evans has been reelected City Engineer of Haverhill, Mass.

Mr. Robert J. Thomas has been reappointed Superintendent of Water-Works of Lowell, Mass.

Mr. Perry T. W. Hale has been appointed Superintendent of Water-Works of Middletown, Conn.

Mr. Wallace McKay, of Tacoma, Wash., has joined the staff of the Alaska Central Ry., as a civil engineer.

Mr. Henry W. Sanderson has been appointed Superintendent of Water-Works of Westfield, Mass., to succeed Mr. Dwight H. Parsons.

Mr. W. O. Lumpkin has resigned his position as Superintendent of the Water-Works and Electric Light Department of Alexandria, La.

Mr. James Billington has been appointed Superintendent of Construction of the new Hudson County court-house, which is to be erected at Jersey City, N. J.

Mr. W. U. Polk has been appointed Assistant Engineer of the Railway Division of the Maryland, Delaware & Virginia Ry., with headquarters at Love Point, Md.

Mr. S. D. Cushing has resigned his position as Signal and Electrical Engineer of the Southern Ry., and will become Assistant to the President of J. B. Semple & Co., Pittsburg, Pa.

Mr. C. L. Crugar, hitherto Chief Clerk to J. E. Willoughby, Chief Engineer of Construction, at Knoxville, Tenn., has been appointed Resident Engineer of the Louisville & Nashville R. R., at La Follette, Tenn.

Mr. J. H. Hadley, hitherto Roadmaster of the Missouri Pacific Ry., at Independence, Kan., has been transferred to Little Rock, Ark., where he will act as Division Engineer of the St. Louis, Iron Mountain & Southern R. R.

Mr. E. B. Boye, for the past five years connected with the Chicago branch of Manning, Maxwell & Moore, Railway and Machinists' Tools and Supplies, has been appointed Manager of the Cleveland (Ohio) office of the firm.

Mr. H. Rettinghouse, formerly Foreman of Bridges and Buildings of the Chicago & Northwestern Ry., at Kaukauna, Wis., has been appointed Division Engineer of the Wisconsin Central Ry., with headquarters at Fond du Lac, Wis.

Mr. Charles Hall Fitch, M. Am. Soc. C. E., has been appointed Supervising Engineer in charge of the U. S. Reclamation Service in Colorado, with headquarters at Denver, to succeed Mr. A. L. Fellows, who has resigned to become State Engineer of North Dakota.

Mr. C. L. Nichols has been appointed Superintendent of the Southwest Division of the Chicago Great Western Ry., to succeed Mr. C. P. Stembel, who has been appointed Superintendent of the Eastern Division, vice Mr. R. W. Edwards, resigned to accept service elsewhere.

Mr. E. P. Neuschwander has left the service of the Engineering Department of the Pennsylvania R. R. Co., and has accepted a position as draftsman in designing, in the Engineering Department of the New York Central & Hudson River R. R. He will be stationed at New York City.

Mr. Waldo C. Briggs, until recently with the Degnon Contracting Co., on their contract for construction of Section 5 A of the Rapid Transit Subway in New York City, has accepted a position with the New York Contracting Co., as Resident Engineer on its Pennsylvania Terminal contract.

Mr. Cecil B. Smith, of Toronto, Ont., formerly Resident Engineer of the Canadian, Niagara Power Co., at Niagara Falls, Ont., has been appointed chairman of the commission recently appointed by the Ontario Government to superintend the building of the Temiskaming & Northern Ontario R. R., a government line.

Mr. N. D. Phelps, who was recently appointed District Manager for the Allis-Chalmers Co., with headquarters at Spokane, Wash., was formerly head of the Mining Department of the Union Iron Works, of San Francisco, Cal. He is a graduate of the Mining Engineering Department of the University of California.

Captain John A. B. Smith, Chief of the Steam Engineering Department at the New York Navy Yard, has been placed on the retired list, through the operation of the age limit. He will be succeeded by Captain George H. Kearney, who has been in charge of a similar department at the Boston Navy Yard. Although his name has been taken from the active list, Captain Smith, who, in the future will have the rank of Rear Admiral, will continue to serve the navy, as he has been appointed General Inspector of the work being done for the navy at all the shipbuilding yards on the Atlantic Coast.

Mr. C. A. Alderman has resigned his position with the Appleyard system of electric railways in Ohio, to become Engineer of Construction with the Cincinnati Northern Traction Co.—a new company organized to take over the old Cincinnati, Dayton & Toledo electric line between Cincinnati and Dayton. Mr. Alderman was Chief Engineer for the construction of Dayton, Springfield & Urbana Electric Ry., Columbus, London & Springfield Ry., Columbus, Buckeye Lake & Newark Ry., Columbus, Newark & Zanesville Ry., and Urbana, Bellefontaine & Northern Ry., and since last December he has been acting as General Superintendent of the first named road. Mr. Alderman, for the present, will have his headquarters in the Traction Building, Cincinnati, O.

Obituary.

William Luddington, a civil engineer of St. Louis, Mo., died March 12 at Washington, D. C., of smallpox.

James Regan, a former paving contractor of Brooklyn, N. Y., died March 13 at his home in that city.

Richard Rosenstock, a civil engineer, died suddenly March 12 at his home in Chicago, Ill., of rheumatism of the heart.

George B. Carhart, at one time President of the New York, New Haven & Hartford R. R., died March 17 at his home in Brooklyn, N. Y., aged 93.

Fred. Stockton, an engineer in the employ of the U. S. Reclamation Service, committed suicide March 2 at Boise, Idaho, by shooting himself through the head. He resided formerly at Sheridan, Ore.

Jeremiah D. Mallory, senior member of the railway supply firm of J. D. Mallory & Co., died March 16 at his home in Baltimore, Md. Mr. Mallory was a thirty-third degree Mason. He was 55 years old.

Luke Moone, a contractor and banker, died March 18 at Kingston, N. Y. As a contractor he furnished most of the stone used in the construction of the Brooklyn Bridge. He also built the sea wall at the Battery, New York City, and parts of the Erie Canal.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 25 to 27. Annual meeting at Boston and Cambridge, Mass. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

NATIONAL MUNICIPAL LEAGUE.
April 25 to 28. Annual convention at New York, N. Y. Secy., C. R. Woodruff, Philadelphia, Pa.

INTERNATIONAL RAILWAY CONGRESS.
May 3 to 15, 1905, at Washington, D. C. Secy. of American Committee, W. F. Allen, 24 Park Place, New York.

AMERICAN WATER-WORKS ASSOCIATION.
May 8 to 12, 1905. Annual meeting at West Baden, Ind. Secy., J. M. Diven, Charleston, S. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May, 1905. Annual spring convention, at Scranton, Pa. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
May 16, 1905. Annual meeting at New York, N. Y.

MASTER CAR BUILDERS' ASSOCIATION.
AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 19 to 23, 1905. Annual convention at Asheville, N. C. Secy., R. W. Pope, 95 Liberty St., New York, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

AMERICAN ELECTROCHEMICAL SOCIETY.—The New York section will hold a social meeting at the Chemists' Club, 108 W. 55th St., New York, on Saturday, March 25, at which Mr. P. L. T. Héroult, of La Praz, France, will be guest. Secy., A. von Isakovics.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—At the regular meeting of March 15, held at the society house, 220 W. 57th St., New York City, Mr. G. F. Stickney read a paper entitled "The Compensating Works of the Lake Superior Power Co." The paper was not discussed.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.—A paper on "Wooden Stave Pipe," by W. C. Hawley, was on the programme for the society's meeting of March 21. The Mechanical Section will meet on April 4; Mr. J. L. Moore will present a paper entitled "Superheated Steam." The society has arranged for four monthly informal dinners, on the evening of the meeting of the society and the Mechanical Section respectively, the dinner, set for 6.30, preceding the meeting.

NEW YORK ELECTRICAL SOCIETY.—At the meeting of March 15, held at 19 W. 44th St., New York City, Mr. E. F. Roeber presented a review of the present status of electrometallurgy, with special reference to iron metallurgy. Mr. P. L. T. Héroult, who was guest at the meeting, spoke briefly on "Steel Making in the Electric Furnace." A striking feature of his remarks was his expressed faith in the simplest type of furnace—a containing vessel wholly or in part of carbon, and an electrode projecting into it—as the best form of furnace for industrial working.

SEATTLE BRANCH, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The Seattle Branch has changed its meeting night to the second Tuesday of the month, and will hereafter meet in the rooms of the Pacific Northwest Society of Engineers except on special occasions. The last meeting was held in the rooms of the Pacific Northwest Society of Engineers, Tuesday, March 14, 1905, at 8, with 13 present. Mr. S. C. Lindsay in the chair. The resignation of Mr. W. V. Sullivan as secretary was accepted, and Mr. Walter S. Wheeler was chosen to fill his place. The paper in the Transactions on "Central Station Design" was read and discussed. Mr. A. T. West, Manager of the Western Union Telegraph Co., gave an informal talk on "Wireless Telegraphy on the Pacific Coast," which was freely discussed. Secy., W. S. Wheeler.

NEW YORK RAILROAD CLUB.—"Developments in Electric Traction," the paper read by Mr. W. B. Potter (General Electric Co.) at the January meeting of the club, was again taken up at the meeting of March 17, in order to give opportunity for more general discussion. After a brief introduction by Mr. Potter, the discussion was opened by Mr. N. W. Storer (Westinghouse Elec. & Mfg. Co.). Stating the concensus of the previous discussion as being strongly for electric main-line traction and distinctly unfavorable to the third-rail as a means therefor, Mr. Storer approved both these sentiments. He believes that the third-rail is not to see extensive use because it must always be an obstruction and a source of danger, it being impossible to protect it in proper manner to eliminate or greatly reduce the danger. Discussing, then, the various systems of traction, he expressed the conclusion that the single-phase alternating-current system, using a commutator motor, is the only system now known that is suitable for main-line traction. A somewhat different conclusion was presented by Mr. A. H. Armstrong (General Electric Co.). An 18-mile line in the west, of 1½% average grade, operating 1,000-ton trains, was made the subject of a study of direct-current traction. The installation cost figured out so high as to make the electric proposition uneconomical. More recently the same road was again studied, but for alternating-current traction, with the result that an earning power of 12 to 15% on the cost of equipment is promised. Either the polyphase of the single-phase system is applicable to this road, with about equal results in the two cases. In the general railway case, however, the single-phase system would be the only alternating-current system to be thought of for main-line work.

Mr. I. A. Hubbell at some length expressed his utter disbelief in the future application of electricity to steam railways. On the contrary, he claimed that a steam locomotive can be built to-day to produce power at 22 lbs. water per I. HP., if simple, or 18 lbs. if compounded. He asserted that we could in five years develop steam traction to transport freight as cheaply as river carriage. Mr. Frank J. Sprague, speaking on electric traction, said the 600-volt standard pressure has come about more or less blindly, without good reason, following his use of that pressure in early experiments on the Manhattan Elevated Ry. It is an example of the power of conservatism and imitation even in electrical work. He believes that we have not by far reached the limits of direct-current traction, either in distribution or in utilization. Moreover, even at the standard pressure, it is to-day no settled question whether in a given railway case the d. c. or the a. c. system would be the better. Referring to the third-rail question, he predicted that the New York Central installation will show a form of third-rail that is free from most of the objections hitherto urged against the third-rail. It would be free from danger, would permit higher pressures, etc. This belief was also expressed, later, by Mr. W. B. Potter.

In further discussion there were remarks by Mr. E. W. Rice, Mr. M. N. Forney, Prof. H. W. Hibbard, and others. Mr. Forney expressed the comforting sentiment that "There's nothing so uncertain as things that are not quite sure," and Mr. Hibbard criticized some of the cost figures of Mr. Potter's paper as giving a deceptive comparison of steam and electric traction unless fixed charges were included. He suggested that the electric manufacturers should follow Corliss' method: offering to take their pay out of savings realized in operation. Mr. Sprague replied that this very method was used in a proposition made to the Manhattan Elevated Ry. about ten years ago, but the letter was not even answered.